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ORTHOSILICATES OF THE ALKALINE EARTHS WITH SPECIAL REFERENCE TO THEIR USES IN THE REFRACTORY FIELD*

By Gilbert E. Seil† and Staff‡

Abstract

The orthosilicates of barium, strontium, calcium, and magnesium; mixed orthosilicates; and mixtures of the orthosilicates of the alkaline earth group are discussed. The effect of periclase on these types of orthosilicates at high temperatures is described. Tabulations are given of the physical properties and chemical compositions of the orthosilicates, including their chemical and mineralogical names, melting points, decomposition points, molecular weights, chemical compositions, crystalline systems, indices of refraction, optical signs, specific gravities, and specific volumes. New data and many illustrations are submitted to show the range of critical temperatures at which reactions take place and at which stabilization is effective. The order of formation is discussed in detail with special reference to the effect of the composition of the starting materials on the rate of reaction and on the critical temperatures at which the orthosilicates are formed.

I. Introduction

Orthosilicates of the alkaline earths have been an interesting subject for research as is indicated by the voluminous bibliography in which the literature has been reviewed and abstracted.[1] Findings based on purely scientific and industrial research have been published, but because of the haphazard manner in which most of the industrial research has been carried out, it is only the results of the purely scientific research which can be used as a foundation. It is the purpose of this paper to add accurately determined information, based on molecular relationships and obtained by systematic scientific research, to the data on the alkaline earth orthosilicates in refractory bodies and to discuss the factors which determine the qualities of refractory bodies containing alkaline earth orthosilicates.

The factors to be considered are (1) the molecular composition of the starting materials and the number of alkaline earth bases present, (2) the presence of small amounts of impurities, an important consideration in refractory manufacture, (3) the use of stabilizers or mineralizers, (4) the methods of formation of the orthosilicates, (5) the rate of reaching critical temperatures, (6) the rate of passing critical temperatures, and (7) the maximum temperature to which the materials have been heated. The alkaline earth orthosilicates fall into four classes, viz., simple orthosilicates having the general formula $2RO \cdot SiO_2$; double orthosilicates, $RO \cdot R'O \cdot SiO_2$ or $3RO \cdot R'O \cdot 2SiO_2$; complex orthosilicates, which contain more than two alkaline earth oxides and occur in many combinations, the general formula being $2RO \cdot R'O \cdot R''O \cdot 2SiO_2$; and mixed orthosilicates, mixtures of two or more of the alkaline earth orthosilicates.

The information obtained from phase-rule diagrams is useful to determine the properties either of the grog or of the ground mass, but it is not useful in determining the properties of the finished refractory because the grog and the ground mass differ. It is impossible, for example, from the analysis of a magnesite brick to predict the characteristics of the brick; for this prediction, it is necessary to determine petrographically (1) the various minerals which exist, (2) the relative placement, (3) the composition, and (4) the properties of the components. The information given by a phase-rule diagram assumes that the rate of reaction or the rate of change from one crystal to another is slower than the rate of cooling and that the crystals and minerals, which are found by examination of the powders or thin sections of the quenched sample, therefore indicate exactly the chemical and physical conditions of the particular mixture at high temperatures. Crystals may exist at high temperatures and even in quenched bodies which do not exist in manufactured refractories because there is no quenching or rapid cooling in refractories manufacture.

(1) Starting Materials Are Factors

The composition of the starting materials is an important factor in the manufacture of refractory bodies containing alkaline earth orthosilicates. An orthosilicate may be formed from one set of reagents at one temperature, but the same orthosilicate will be formed from another set of reagents at an entirely different temperature. There are critical temperatures at which the orthosilicates do not form rapidly and other temperatures at which they do form rapidly. The starting materials, therefore, must be chosen in accordance with the properties which the refractories containing alkaline earth orthosilicates are to have.

The reaction between periclase and magnesium metasilicate, for example, does not progress rapidly at the

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[1] G. E. Seil and Staff, "Bibliography on Orthosilicates of the Alkaline Earths with Special Reference to Their Use in the Refractory Field," *Ceram. Abs.*, 19 [11] 273–93 (1940).

melting point of the magnesium metasilicate. Because the magnesium metasilicate is entirely in the liquid phase before the formation of forsterite has been completed, a refractory body made from periclase and magnesium metasilicate as starting materials does not hold itself rigid until the forsterite is formed, and the placement of the forsterite cannot be predetermined. If, on the other hand, the same amount of forsterite is formed from a mixture of periclase and finely ground silica, the rate of formation of forsterite at the temperature at which the reaction takes place between periclase and silica is so rapid that forsterite is formed in the rigid body and its placement can be predetermined.

The ease with which orthosilicates are formed and with which one base replaces another base also depends on the starting materials. When magnesium metasilicate, which melts at a low temperature, is heated with the calculated amount of barium sulfate or calcium sulfate, it readily forms barium or calcium orthosilicate and periclase. Magnesium orthosilicate and the calculated amount of barium sulfate or calcium sulfate, on the other hand, require an appreciably higher temperature than that required with magnesium metasilicate for the conversion to barium or to calcium orthosilicate. Probably the most difficult case is the conversion of calcium orthosilicate to barium orthosilicate by reaction with barium sulfate or barium carbonate in spite of the wide variation in the melting points of the two orthosilicates. Calcium orthosilicate melts at 3866°F. and reacts very slowly at temperatures considerably below its melting point, even when impurities are present which furnish a liquid phase in which both of the reacting materials are soluble and from which the barium orthosilicate can crystallize.

(2) Effect of Temperature

Another important consideration is the effect of temperature on the stability and reactivity of the orthosilicates. If the orthosilicate is formed at the lowest possible temperature, it is quite reactive; if, however, it is heated to a temperature approaching its melting point, its chemical activity decreases and its stability increases. This is true particularly in the case of calcium orthosilicate to which stabilizers, such as phosphoric acid, boric acid, or chromic oxide, have been added. Chrome ore added to an already formed calcium orthosilicate does not stabilize it. To stabilize calcium orthosilicate by Cr_2O_3, calcium chromate must first be formed in the mixture.

(3) Chromite Refractories

The chromite refractories have been revolutionized during the past two decades by the conversion of the lower magnesium silicates to the magnesium orthosilicate as a bond in chrome brick. A similar principle is now applied in the manufacture of low-iron magnesite brick where the ground mass is almost always a mixture of forsterite ($2MgO \cdot SiO_2$) and monticellite ($CaO \cdot MgO \cdot SiO_2$).

(4) Dolomite Refractories

Extensive activity in the development of refractories from dolomite indicates that basic or neutral refractories in brick form made from dolomite as a starting material may be widely used in the future. The best method known to stabilize lime in dolomite is to convert it to stabilized calcium orthosilicate, which has been heated to the critical point at which its chemical activity has been decreased to the lowest possible degree, and to convert substantially all of the magnesia to periclase. Although the conversion takes place at lower temperatures, the products are too active chemically unless the higher critical temperature has been reached to make the orthosilicate and periclase almost chemically inactive.

(5) Relative Reactivity of the Alkaline Earths

There are many critical reactions which are not thoroughly understood or which have not been clearly explained. The order of reactivity of the alkaline earth oxides is BaO, SrO, CaO, and MgO. In any mixture of alkaline earth oxides and silica, the orthosilicate of the most basic oxide will be formed if the proper molecular relationship exists between the alkaline earth oxide and the silica. If the mixture contains BaO and SiO_2 in the molecular ratio of 2:1 or BaO in excess of the 2:1 molecular ratio, barium orthosilicate will be formed, regardless of the presence of the other alkaline earth oxides. If the SiO_2 is in excess of the 2:1 molecular ratio, some double or complex orthosilicates will form in the presence of the other alkaline earth oxides, depending on the relative amounts of the four oxides present.

In a mix containing the critical relationship of 2 moles of SrO to 1 mole of SiO_2 or with SrO in excess of that ratio, strontium orthosilicate will be formed, provided the mix does not contain sufficient BaO to form orthosilicate with the SiO_2 present. Calcium oxide and MgO will not prevent the formation of strontium orthosilicate if the proper proportions of SrO and SiO_2 are present in the reacting mix. Magnesium oxide, similarly, will not prevent the formation of calcium orthosilicate in the absence of BaO and SrO, if the proper proportions of CaO and SiO_2 are present in the reacting mix. When the molecular ratio of CaO to SiO_2 is exactly 2:1 or when the CaO is in excess of a 2:1 molecular ratio, then, even in the presence of MgO but in the absence of BaO and SrO, calcium orthosilicate will be formed and will be the only orthosilicate formed. But if the molecular ratio of CaO and SiO_2 is less than 2:1, monticellite is formed from part or all of the CaO, depending of course on the relative amounts of CaO, MgO, and SiO_2 in the mix.

(6) Reactions Between Alkaline Earth Oxides and Alkaline Earth Orthosilicates

$2BaO$ reacts with $2SrO \cdot SiO_2$, $2CaO \cdot SiO_2$, and $2MgO \cdot SiO_2$.

$2SrO$ reacts with $2CaO \cdot SiO_2$ and $2MgO \cdot SiO_2$ but not with $2BaO \cdot SiO_2$.

$2CaO$ reacts with $2MgO \cdot SiO_2$ but not with $2BaO \cdot SiO_2$ or $2SrO \cdot SiO_2$.

$2MgO$ does not react with any other orthosilicate of the group.

Barium orthosilicate cannot be used in refractory bodies because it is not stable at high temperatures, particularly in the presence of iron oxide. Although what takes place has not been determined, it is known that with constant treatment at high temperatures a refractory containing barium, silica, and iron oxide shows an increase in the barium-silica ratio and that both barium and silica are lost. Barium orthosilicate has the obvious advantage of having a base that is not replaceable by any of the other alkaline earth oxides.

Calcium orthosilicate, formed at temperatures sufficiently high to minimize its chemical activity and to prevent inversion, is very useful in the refractory field. In the presence of periclase and silica, it forms monticellite, which lowers the melting point from 3866° to about 2725°F. Where there is no chance of silica absorption, calcium orthosilicate is a proper refractory. If an excess of lime is present with calcium orthosilicate, difficulties due to hydration are encountered. There are two methods of compensation for the lime in periclase-calcium orthosilicate refractories.

One method depends on balancing the CaO and SiO_2 in the starting material so as to convert all of the CaO present to $2CaO \cdot SiO_2$. The correction may be made in a single or in a double firing. The starting materials, in the latter case, contain approximately equimolecular amounts of CaO and SiO_2 and an excess of MgO, and after intimate mixing they are fired to form monticellite from the CaO, SiO_2, and part of the MgO present. The calculated amount of CaO to form $2CaO \cdot SiO_2$ with monticellite is added to the product thus obtained, and when the mixture is fired the second time, a periclase dicalcium silicate body is formed. Refractories made according to this process were manufactured early in 1936 and were used in the steel industry.

Because the exact balancing of the lime and the silica is a rather delicate commercial operation, a second method for correcting the monticellite always present in dead-burned magnesites was developed in the laboratory of the writers. This method depends on the dispersion or dilution of the monticellite in a relatively larger amount of magnesium orthosilicate. The dilution is accomplished by adding silica to the magnesite and converting the surfaces of the periclase grains to forsterite in which the small amount of monticellite is held in solid solution. The effect of the monticellite is minimized but not completely corrected by dilution.[2]

A dolomite refractory should consist essentially of periclase and properly prepared and stabilized calcium orthosilicate. The presence of a low-melting bonding constituent in the body is essential, however, if the body is to be economically fired in available equipment. The low-melting point bonding constituent must be carefully chosen because the presence of many components in the ground mass invites a confusingly large number of chemical reactions to take place. If, therefore, a low-melting point constituent can be chosen which is composed of the same oxides as the refractory constituent, the number of possible reactions is minimized and correction is made relatively easy. Monticellite, for this reason, was chosen as the low bonding constituent.

A formula, based on analytical data, to determine the weight of monticellite which will be formed by known weights of reacting materials is derived as follows:

Let X = lb. of $2CaO \cdot SiO_2$ formed
Y = lb. of $CaO \cdot MgO \cdot SiO_2$ formed
Because $2CaO \cdot SiO_2$ contains 65.12% of CaO and 34.88% of SiO_2; $CaO \cdot MgO \cdot SiO_2$ contains 35.84% of CaO and 38.39% of SiO_2,

$0.6512X + 0.3584Y$ = lb. of CaO in mixture
$0.3488X + 0.3839Y$ = lb. of SiO_2 in mixture

$(0.6512)(0.3488)X + (0.3584)(0.3488)Y = 0.3488$ (lb. of CaO)

$(0.6512)(0.3488)X + (0.6512)(0.3839)Y = 0.6512$ (lb. of SiO_2)

$0.125Y - 0.250Y = 0.3488$ (lb. of CaO) $- 0.6512$ (lb. of SiO_2)

$0.125Y = 0.6512$ (lb. of SiO_2) $- 0.3488$ (lb. of CaO)

$Y = 5.2096$ (lb. of SiO_2) $- 2.790$ (lb. of CaO).

The amount of monticellite, for example, which will be formed by a mixture of 100 lb. of dolomite and 15.8 lb. of silica, knowing the analyses of the starting materials, is determined as follows:

	CaO	MgO	SiO_2	CO_2
Analysis of dolomite (%)	29.34	22.16	1.29	47.21
Weights of reacting materials				
Dolomite (100 lb.)	29.34	22.16	1.29	
Silica (15.8 lb.)			15.80	
Total	29.34	22.16	17.09	

Weight of product = 68.59 lb.
Weight of monticellite formed (Y) = 5.2096 (17.09) − 2.790 (29.34) = 89.03 − 81.86 = 7.17 lb.

Monticellite (%) in finished body = $\frac{7.17}{68.59} \times 100 = 10.45$.

Weight of CaO reacted to form monticellite = 7.17 (0.3584) = 2.57 lb.
Weight of SiO_2 reacted to form monticellite = 7.17 (0.3839) = 2.75 lb.
Weight of CaO reacted to form calcium orthosilicate = 29.34 − 2.57 = 26.77 lb.
Weight of SiO_2 reacted to form calcium orthosilicate = 17.09 − 2.75 = 14.34 lb.

The CaO and the SiO_2 thus are in exactly the right amounts necessary to form 41.11 lb. of calcium orthosilicate.

Calcium orthosilicate (%) in the finished body = $\frac{41.11}{68.59} \times 100 = 59.94\%$.

The analysis of the finished body is periclase 29.61%, calcium orthosilicate 59.94%, and monticellite 10.45%.

In the foregoing calculations, accurate atomic weights (see G. P. Baxter, O. Hönigschmid, and P. Le Beau, "Sixth Report of Committee on Atomic Weights of International Union of Chemistry," *Jour. Amer. Chem. Soc.*, **58** [4] 541–48 (1936)) were used, and mixtures containing only MgO, CaO, and SiO_2 were considered.

A chart from which the silica additions required to form desired amounts of monticellite with dolomites of given analysis can be determined graphically has been prepared (see Fig. 11, p. 9).

[2] G. E. Seil, "Corrected Magnesia Refractories," U. S. Pat. 2,206,131, July 2, 1940 (Feb. 2, 1937); *Ceram. Abs.*, **19** [9] 217 (1940).

A very refractory grog for brick manufacture was made by adding sufficient silica to dolomite to convert all of the lime to calcium orthosilicate plus a slight excess of silica to produce a body containing a small amount (1 or 2%) of monticellite. This amount of monticellite, furthermore, insured the complete conversion of the lime to orthosilicates. The grog must be fired so that all of the residual shrinkage has been removed and the chemical activity of the stabilized calcium orthosilicate has been reduced to a minimum. This grog, low in monticellite, ground to the proper grain size and fired, cannot be fired to form a sound brick with available commercial equipment. A second mix, to yield a body containing approximately 15% of monticellite, was therefore prepared, fired, and ground so that all of it passed 100-mesh and was mixed in the proper proportions with the properly sized grog of the first body. The mixture was then fired to make the finished brick. The lower melting-point material in this way was placed in thin films on the grain surfaces of the grog. A migration of monticellite takes place which slightly lowers the melting point of the grog surface and increases that of the bonding addition.

Magnesium orthosilicate is the most useful of the alkaline earth orthosilicates as a refractory material because it exists only in one form and because it is not decomposed by water as is barium orthosilicate. An excess of magnesia improves the refractory properties of magnesium orthosilicate, whereas an excess of barium or lime decreases the refractory value of barium orthosilicate and of calcium orthosilicate. The absorption of silica by refractories containing forsterite and periclase furthermore is not deleterious because the silica forms more forsterite. The absorption of calcium orthosilicate or lime by refractories containing forsterite is deleterious because monticellite is formed and lowers the refractory properties of the body. A great advantage of magnesium orthosilicate lies in the fact that, in addition to the qualities already mentioned, its rate of formation and its placement can be controlled.

(7) Three Methods of Making Magnesite Brick

The placement of the various components of refractory bodies has been mentioned from time to time. To illustrate the importance of placement and of the choice of starting materials, three methods for the manufacture of magnesite brick bonded with the same amount of forsterite are described. The brick are of the same chemical analysis and of the same mineral compositions, but the minerals are differently placed in the finished products.

Brick No. 1: The starting materials were finely ground low iron periclase and finely ground silica intimately mixed, clinkered at high temperature, recrushed to a predetermined screen size, tempered, pressed, dried, and fired. Each grain in this body consisted of periclase crystals interspersed with forsterite and monticellite. The material was almost homogeneous, and the brick was no better than one made of low iron periclase alone. It could not be fired at a higher temperature, it spalled in the same range, and it was not appreciably better under load at high temperature.

Brick No. 2: The starting materials were a carefully sized grog of the same type of low iron periclase and finely ground silica, mixed, tempered, pressed, dried, and fired. Only one firing operation was required to produce the finished product. Each grain of periclase in this body was composed of crystals of periclase, but the individual grains were coated and bonded with a film of forsterite formed from the surfaces of two adjacent periclase grains. Brick No. 2 withstood 600°F. higher firing temperature than brick No. 1 without any deformation, cracking, or warpage. Its load test was better than any other brick tested. The spalling was low, and it was as good generally as any brick ever made in the writers' laboratory.

Brick No. 3: The starting materials, namely, carefully sized grog of low iron periclase of the same type as used in brick No. 1 and brick No. 2 and finely ground magnesium metasilicate (no loss on ignition), were tempered, pressed, dried, and fired. The metasilicate, during the firing, melted faster than forsterite could form at the melting point of the metasilicate, and the brick warped, cracked, and deformed at firing temperatures lower than that used in firing brick No. 1.

The method used in the first example to arrive at the data for phase-rule diagrams by homogeneously distributing the solids in periclase was approached. Thin films of forsterite, in the second example, were carefully placed on the surface of each grain of periclase, and periclase grog in the ground mass of forsterite crystals was obtained. The forsterite was formed from the surfaces of the periclase grains by reaction with the finely ground silica surrounding each grain. The important consideration in this example is the fact that no liquid phase existed until the critical temperature at which forsterite forms rapidly was passed; therefore, when the reaction took place, only forsterite formed from the magnesia and the silica. In the third example, where magnesium metasilicate was the source of silica, the rate of formation of forsterite was relatively slow at the melting point of the metasilicate. The brick therefore could not hold its shape under its own weight owing to the fusion of the metasilicate without appreciable reaction with the surfaces of the periclase grog.

(8) Orthosilicates for Furnace Bottoms

Only the use of orthosilicates in brick has been considered up to this point. In materials for furnace bottoms, an entirely different product is required. If the reactions have been completed before the grain is used, an exceedingly high temperature is required to fire the material into the bottom. There are several methods of avoiding this. One method consists of heating the material to a point at which reaction starts but is not complete and then allowing the reaction to finish after the material has been placed in the furnace. This is probably the best method because a carefully predetermined chemical analysis and physical condition may be maintained. Another method, which is largely used in industry, is to take a very hard-fired, completely

TABLE I

CHEMICAL COMPOSITIONS AND MELTING POINT DATA OF THE ORTHOSILICATES OF THE ALKALINE EARTHS

Refractory material	Mineral name and formula	Melting point data	Molecular weight	MgO	CaO	SrO	BaO	SiO_2
Magnesium orthosilicate	$2MgO \cdot SiO_2$ Forsterite	3434°F.*†	140.70	57.31% $MgO = (1.3425)(SiO_2)$				42.69% $SiO_2 = (0.7449)(MgO)$
Calcium orthosilicate	$2CaO \cdot SiO_2$ Larnite	α-stable 2588°–3866°F.*†	172.22		65.13% $CaO = (1.8678)(SiO_2)$			34.87% $SiO_2 = (0.5354)(CaO)$
Dicalcium silicate, sometimes called lime-olivine	Shannonite	β-stable 1247°–2588°F., inversion from β to γ accompanied by 10% increase in volume*† γ-stable below 1247°F.*†						
Magnesium calcium orthosilicate	$CaO \cdot MgO \cdot SiO_2$ Monticellite	Decomposes, before melting at 2728°F.,* into calcium orthosilicate and forsterite; made from fusion at about 2714°F.†	156.46	25.77% $MgO = (0.7190)(CaO)$ $MgO = (0.6713)(SiO_2)$	35.84% $CaO = (1.3908)(MgO)$ $CaO = (0.9336)(SiO_2)$			38.39% $SiO_2 = (1.0712)(CaO)$ $SiO_2 = (1.4897)(MgO)$
Magnesium tricalcium diorthosilicate	$3CaO \cdot MgO \cdot 2SiO_2$ Merwinite	"It is probably a low-temperature form, breaking down before its melting point is reached; its association with wollastonite indicates that it crystallizes below 2174°F., the inversion temperature of wollastonite"‖	328.68	12.27% $MgO = (0.2397)(CaO)$ $MgO = (0.3358)(SiO_2)$	51.19% $CaO = (4.1720)(MgO)$ $CaO = (1.4009)(SiO_2)$			36.54% $SiO_2 = (0.7138)(CaO)$ $SiO_2 = (2.9780)(MgO)$
Strontium orthosilicate	$2SrO \cdot SiO_2$	Probably more than 3191° F.*; made by heating at high temperatures†; m. p. far above range of Pt resistance furnace§	267.30			77.53% $SrO = (3.4504)(SiO_2)$		22.47% $SiO_2 = (0.2808)(SrO)$
Barium orthosilicate	$2BaO \cdot SiO_2$	Jaeger and Van Klooster: m. p. exceeds 3182°F.§; m. p. more than 3191°F.*; m. p. about that of Pt†; made from fusion†; m. p. higher than that of Pt‖; granular mass of rounded grains showing no cleavage or twin	366.80				83.63% $BaO = (5.1087)(SiO_2)$	16.37% $SiO_2 = (0.1957)(BaO)$
Ferrous orthosilicate	$2FeO \cdot SiO_2$ Fayalite	2291°F.*	203.74	FeO, 70.52% $FeO = (2.3021)(SiO_2)$				29.48% $SiO_2 = (0.4180)(FeO)$

* International Critical Tables of Numerical Data, Physics, Chemistry, and Technology. International Research Council, 1926–1930.

† A. N. Winchell, Microscopic Characters of Artificial Inorganic Solid Substances or Artificial Minerals, 2d ed. John Wiley & Sons, New York, 1931.

§ Pentti Eskola, "Silicates of Strontium and Barium," *Amer. Jour. Sci.*, [5] **4**, 331 (1922).

‖ E. S. Larsen and W. F. Foshag, "Merwinite, a New Calcium Magnesium Orthosilicate from Crestmore, Calif.," *Amer. Mineralogist*, 6 [10] 143–48 (1921).

reacted material and mix it with fusible materials, such as slag, allowing the slag to react with and fuse together the high-priced, dead-burned material. This reaction is almost uncontrollable. The less time taken for firing in a bottom by this method, the poorer the result. Usually only enough time is taken in firing in the bottom to allow the reactions to take place on the extreme surfaces of the grains, and therefore a liquid phase is found in the bottom at working temperatures. A third method, one which is probably equal to the first method described, is to prepare a very infusible dense grog and coat it with finely divided, more fusible grain, which will act as a cementing material at the temperature of furnace operation. The fusibility of the two materials varies to an appreciable extent when they are placed in the furnace, but a migration occurs when heat is applied which causes the bonding materials to be absorbed and adsorbed by the more difficultly fusible and rigid grains.

TABLE II

OPTICAL PROPERTIES OF THE ORTHOSILICATES OF THE ALKALINE EARTHS

Refractory material	Mineral name and formula	Reference	Crystal system	α	β	γ	γ − α	Optic sign
				Indices of refraction			Birefringence	
				N_p	N_m	N_g	N_g-N_p	
Magnesium orthosilicate	$2MgO \cdot SiO_2$	*	Rhombic	1.635	1.651	1.670	0.035	
	Forsterite	†	Orthorhombic	1.6359(D)	1.6507 (D)	1.6688 (D)	0.0329	Positive
		‡	"	1.636	1.651	1.669	0.033	
Calcium orthosilicate (dicalcium silicate sometimes called lime-olivine)	$2CaO \cdot SiO_2$	*	Monoclinic-triclinic	1.715	1.720	1.737	0.022	
	Larnite	†	Monoclinic (?)	1.715	1.720	1.737	0.023 Na	"
		‡	Monoclinic	1.707	1.715	1.730	0.023	
	Shannonite	*	Monoclinic-rhombic	1.717		1.735	0.018	
		†	Orthorhombic	1.717		1.735	0.018	"
		*	Monoclinic	1.642	1.645	1.654	0.012	
		†	Monoclinic (?)	1.642	1.645	1.654	0.013	"
Magnesium calcium orthosilicate	$CaO \cdot MgO \cdot SiO_2$ Monticellite	*	Rhombic	1.651	1.662	1.668	0.017	
				(Values for monticellite containing 4.8% FeO and 1.6% MnO)‡				
		†	Orthorhombic	1.638–1.640	1.646	1.651–1.655	0.015	"
				(Values for monticellite 10% $2MgO \cdot SiO_2$)				
		†	"	1.663	1.674	1.680	0.018	Negative
				(Values for monticellite 16% $(Mg, Fe)_2SiO_4$)				
		‡	"	1.639	1.646	1.653	0.014	
				(Values for c.p. material, Fe free)				
Magnesium tricalcium diorthosilicate	$3CaO \cdot MgO \cdot 2SiO_2$	*	Monoclinic	1.708	1.711	1.718	0.010	
	Merwinite	†(Part II)	"	1.708	1.711	1.718	0.010	Positive
		‡	"	1.708	1.711	1.718	0.010	
Strontium orthosilicate	$2SrO \cdot SiO_2$	*		1.727 (D)	1.732 (D)	1.756 (D)	0.029 (D)	
		†	Probably monoclinic	1.7275 (D)	1.732 (D)	1.756 (D)	0.0285 (D)	"
		§	" "	1.7275 (D)	1.732 (D)	1.756 (D)	0.0285 (D)	"
Barium orthosilicate	$2BaO \cdot SiO_2$	*		1.810		1.830	0.020	
		†		1.810		1.830	0.020 (D)	
		§		1.810 (D)		1.830 (D)	0.020 (D)	
Ferrous orthosilicate	$2FeO \cdot SiO_2$	*	Rhombic	1.835	1.877	1.886	0.051	
	Fayalite	†	Orthorhombic	1.835	1.877	1.886	0.051	Negative
		‡	"	1.835	1.877	1.886	0.051	

* International Critical Tables of Numerical Data, Physics, Chemistry, and Technology, International Research Council, 1926–1930.

† A. N. Winchell, Microscopic Characters of Artificial Inorganic Solid Substances or Artificial Minerals, 2d ed. John Wiley & Sons, New York, 1931.

‡ E. S. Larsen and Harry Berman, "Microscopic Determination of the Nonopaque Minerals," *U. S. Geol. Surv. Bull.*, No. 848 (2d ed., 1934); *Ceram. Abs.*, **13** [7] 196 (1934).

§ Pentti Eskola, "Silicates of Strontium and Barium," *Amer. Jour. Sci.*, [5] **4**, 331–75 (1922).

TABLE III

Refractory material	Formula	Chemical analysis						Firing temp. (°F.)	Melting point (°F.)
		CaO	MgO	SiO_2	P_2O_5	Cr_2O_3	B_2O_3		
100% forsterite	$2MgO \cdot SiO_2$		57.31	42.69				2600	
Magnesium orthosilicate			57.02	42.48	0.50			2890	
								3040	
			57.02	42.48	0.50			3020	
			56.73	42.27	1.00				
			57.02	42.48		0.50		3020	
			56.73	42.27		1.00			
			57.02	42.48			0.50	3020	
			56.73	42.27			1.00		
50% forsterite 50% periclase	50% $2MgO \cdot SiO_2$ 50% MgO		78.26	21.24	0.50			3020	No fusion

II. Experimental Data and Results

Tabular data and figures, showing experiments on which the general discussion is based, are presented.

Table III is a tabulation of the actual chemical analyses of a series of pellets containing a mixture calculated to yield forsterite after firing at various temperatures with and without stabilizing agents; the mixture contains periclase equal in weight to the calculated amount of forsterite. The original pellets in this case (and in every case described in this paper) were prepared from c.p. chemicals, using the required oxides, carbonates, or hydroxides.

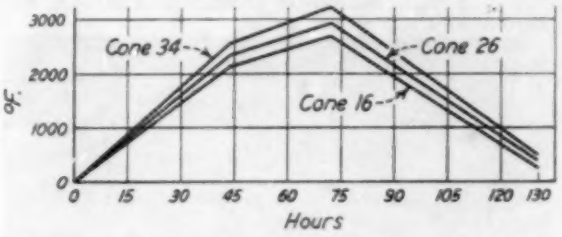


FIG. 1.—Time-temperature curves on which various pellets were fired.

Figure 1 shows the time-temperature curves on which the various pellets were fired.

Figures 2 to 8, inclusive, cover the pellets which were calculated to yield forsterite. Only a small portion of the shrinkage has been fired out of the pellets at 2600°F., and only a portion of the mass has reacted; 40% of forsterite, 40% of clinoenstatite, and about 20% of periclase has been formed. The presence of P_2O_5 retards the formation of forsterite. At 2890°F., there is considerably less shrinkage, and 60% of the mass has been converted to forsterite. The presence of P_2O_5 again retards the formation of forsterite so that only 40% of forsterite was formed, instead of 60% without P_2O_5. Most of the shrinkage has occurred at 3040°F. and, when no P_2O_5 is present, forsterite is the only mineral formed. The presence of P_2O_5, Cr_2O_3, or B_2O_3, however, retards the formation of forsterite. Note that the Cr_2O_3 does not react with the magnesia sufficiently to discolor the pellets at 3020°F.

Figure 9 compares forsterite and barium orthosilicate as bonds for magnesite brick. The conversion of the silica to barium orthosilicate was not completed at 2900°F., owing to the fact that the barium sulfate was added to periclase in which all of the silica was previously converted to forsterite and monticellite, and forsterite reacts very slowly with barium sulfate. There was also a considerable amount of shrinkage when brick No. 3 was fired, even more than in the magnesite brick without any added bond. Brick No. 2 shows the effect of increasing the amount of forsterite from 7 to 33% as a diluent for the monticellite. By the formation of a relatively large amount of forsterite, the deleterious effect of the monticellite was minimized. Note that brick No. 2 was made by the addition of pure and finely ground silica to carefully sized, low-iron magnesite.

TABLE IV

FORSTERITE SERIES

(2 moles of MgO:1 mole of SiO_2)

Figure No.	Additions (%)	Firing temp. (°F.)	Petrographic analysis (±10%)* Forsterite†	Clinoenstatite	Periclase
2	None	2600	40	40	20
2	0.5 P_2O_5	"	30	50	20
3	None	2890	60	30	10
3	0.5 P_2O_5	"	40	40	20
4	None	3040	100		
4	0.5 P_2O_5	"	40	40	20
5	0.5 P_2O_5	3020	50	35	15
5	1.0 P_2O_5	"	40	40	20
6	0.5 Cr_2O_3	"	75	20	5
6	1.0 Cr_2O_3	"	45	40	15
7	0.5 B_2O_3	"	75	20	5
7	1.0 B_2O_3	"	65	25	10
8	0.5 P_2O_5 50 MgO	"	30	15	55

* The petrographic analysis was made on residual material in each case of pellets (see Figs. 2 to 8, inclusive).

† The formation of forsterite is retarded by the addition of P_2O_5, B_2O_3, and Cr_2O_3, which stabilizes calcium orthosilicate.

(1) (2) (3)

FIG. 9.—Comparison of three types of magnesite brick bonded with orthosilicates and fired at cone 26 (2903°F.): (1) Magnesite brick; (2) forsterite-bonded (from MgO and SiO_2) magnesite brick; and (3) barium orthosilicate-bonded magnesite brick.

	Chemical analysis (%) Brick No. (1)	(2)	(3)
MgO	90.80	78.24	72.24
CaO	2.23	1.93	1.43
SiO_2	5.34	16.12	4.51
Fe_2O_3	1.02	2.62	1.52
Al_2O_3	0.37	0.79	0.56
BaO			14.03
SO_4			6.11
Petrographic analysis (%)			
Periclase	84.83	57.02	68.20
Forsterite	6.91	32.91	6.00
Monticellite	6.22	5.39	
$MgO \cdot Fe_2O_3$	1.28	3.28	1.90
$MgO \cdot Al_2O_3$	0.52	1.10	0.78
Barium sulfate			14.85
Undeterminable orthosilicates			8.27

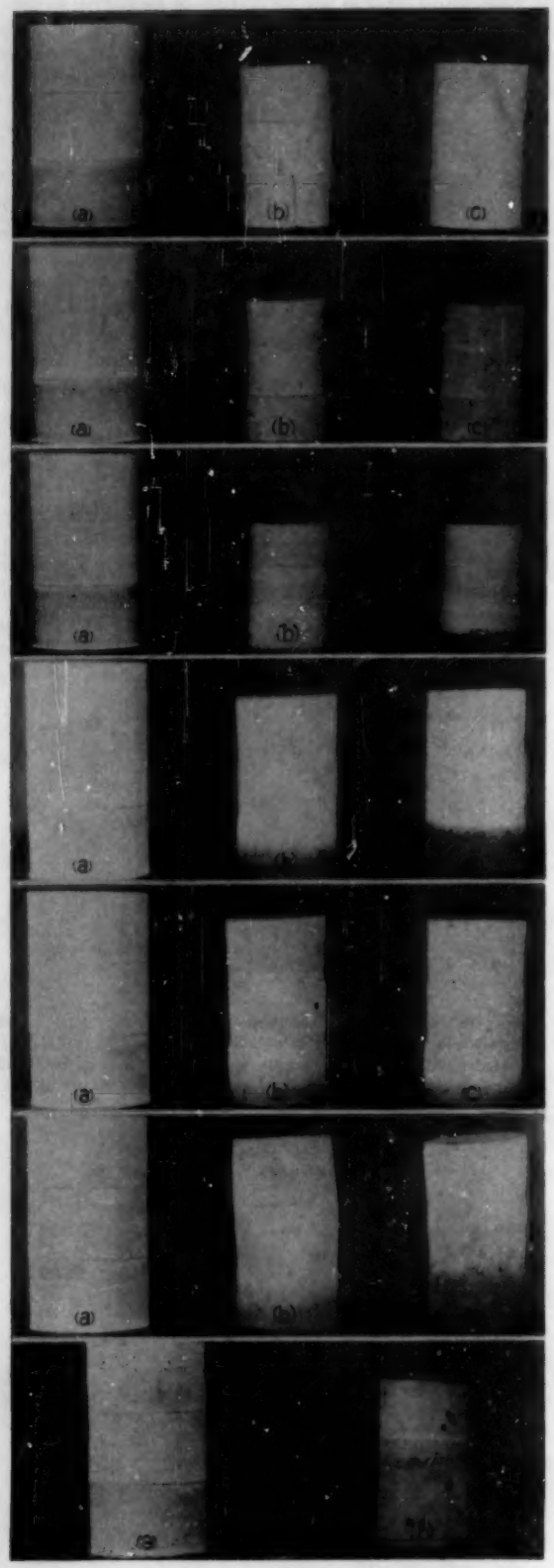


FIG. 2.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2600°F.: MgO 57.31% and SiO_2 42.69%.
(*c*) Chemical analysis of product fired at 2600°F.: MgO 57.02%, SiO_2 42.48%, and P_2O_5 0.50%.

FIG. 3.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2890°F.: MgO 57.31% and SiO_2 42.69%.
(*c*) Chemical analysis of product fired at 2890°F.: MgO 57.02%, SiO_2 42.48%, and P_2O_5 0.50%.

FIG. 4.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3040°F.: MgO 57.31% and SiO_2 42.69%.
(*c*) Chemical analysis of product fired at 3040°F.: MgO 57.02%, SiO_2 42.48%, and P_2O_5 0.50%.

FIG. 5.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: MgO 57.02%, SiO_2 42.48%, and P_2O_5 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: MgO 56.73%, SiO_2 42.27%, and P_2O_5 1.00%.

FIG. 6.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: MgO 57.02%, SiO_2 42.48%, and Cr_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: MgO 56.73%, SiO_2 42.27%, and Cr_2O_3 1.00%.

FIG. 7.
FORSTERITE ($2MgO \cdot SiO_2$)
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: MgO 57.02%, SiO_2 42.48%, and B_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: MgO 56.73%, SiO_2 42.27%, and B_2O_3 1.00%.

FIG. 8.
FORSTERITE ($2MgO \cdot SiO_2$) 50% AND PERICLASE 50%
(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: MgO 78.26%, SiO_2 21.24%, and P_2O_5 0.50%.

Figure 10 shows magnesite brick bonded with forsterite fired under similar conditions to brick No. 2 in Fig. 9 but in which an equivalent amount of silica was supplied by the addition of magnesium metasilicate. The brick, after firing, contained the same amount of periclase and forsterite as brick No. 2 in Fig. 9, but a decided difference in firing properties is apparent, owing to the fact that magnesium metasilicate melted at a point at which forsterite develops very slowly; the brick therefore warped and distorted before enough forsterite was formed to furnish a rigid bond. In brick No. 2 (Fig. 9), the reaction between the periclase and the silica yielded forsterite without forming any low-melting intermediate silicate.

FIG. 10.—Forsterite-bonded (from MgO and $MgO \cdot SiO_2$) magnesite brick fired at cone 27 (2925°F.). Chemical analysis: MgO 78.24%, CaO 1.93%, SiO_2 16.12%, Fe_2O_3 2.62%, and Al_2O_3 0.79%. Petrographic analysis: Periclase 57.02%, forsterite 32.91%, monticellite 5.39%, $MgO \cdot Fe_2O_3$ 3.28%, and $MgO \cdot Al_2O_3$ 1.10%.

Figure 11 is a chart for determining the amount of monticellite and calcium orthosilicate which will be formed in any mixture or the amount of silica necessary to form a predetermined percentage of calcium orthosilicate and monticellite.

Table V is a tabulation of the actual chemical analyses of a series of pellets made from a mixture calculated to yield calcium orthosilicate, fired at different temperatures, with and without stabilizing materials and with periclase equal in weight to the calculated amount of calcium orthosilicate.

Figure 12, which shows the pellets containing mixtures to yield calcium orthosilicate with and without P_2O_5 after heating to 2600°F., indicates definitely

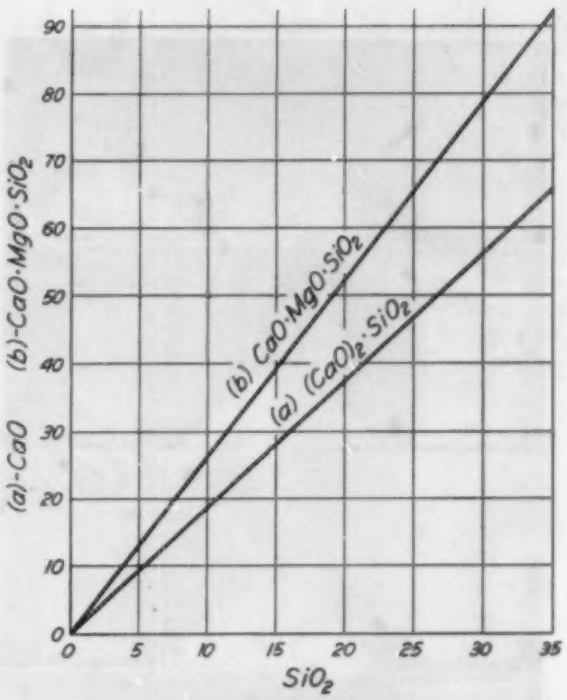


FIG. 11.—$2CaO \cdot SiO_2$ (SiO_2 34.88% and CaO 65.12%); $CaO \cdot MgO \cdot SiO_2$ (SiO_2 38.39%, CaO 35.84%, and MgO 25.77%). To determine the $CaO \cdot MgO \cdot SiO_2$ formed, (1) find SiO_2 equivalent to CaO in the mix using line (*a*); (2) subtract SiO_2 from (1) from total SiO_2; and (3) double SiO_2 from (2), and find corresponding $CaO \cdot MgO \cdot SiO_2$ using line (*b*). Note: Double SiO_2 from (2) must be equal to or less than total SiO_2. To determine SiO_2 addition to form a definite amount of $CaO \cdot MgO \cdot SiO_2$, (1) find pounds of SiO_2 equivalent to CaO in sample using line (*a*); (2) find SiO_2 equivalent to the required $CaO \cdot MgO \cdot SiO_2$; (3) total SiO_2 = SiO_2 from (1) + $\frac{1}{2}SiO_2$ from (2); and (4) SiO_2 addition = SiO_2 from (3) − SiO_2 in mix.

that P_2O_5 does not stabilize calcium orthosilicate at 2600°F.

Figure 13 shows that 0.5% of P_2O_5 stabilized calcium orthosilicate at 2890°F. The calcium orthosilicate formed at this temperature is quite active chemically.

Figures 14 and 15 show that the P_2O_5 stabilized the calcium orthosilicate at 3040°F. and that the calcium orthosilicate is almost inactive chemically. It is not affected by water or by steam as are the pellets fired

TABLE V

Refractory material	Formula	Chemical analysis						Firing temp. (°F.)	Melting point (°F.)
		CaO	MgO	SiO_2	P_2O_5	Cr_2O_3	B_2O_3		
100% calcium orthosilicate	$2CaO \cdot SiO_2$	65.13		34.87				2600	
		64.80		34.70	0.50			2890	
								3040	
		64.80		34.70	0.50			3020	
		64.48		34.52	1.00				
		64.80		34.70		0.50		3020	
		64.48		34.52		1.00			
		64.80		34.70			0.50	3020	
		64.48		34.52			1.00		
50% calcium orthosilicate 50% periclase	50% $2CaO \cdot SiO_2$ 50% MgO	32.40	49.75	17.35	0.50			3020	No fusion

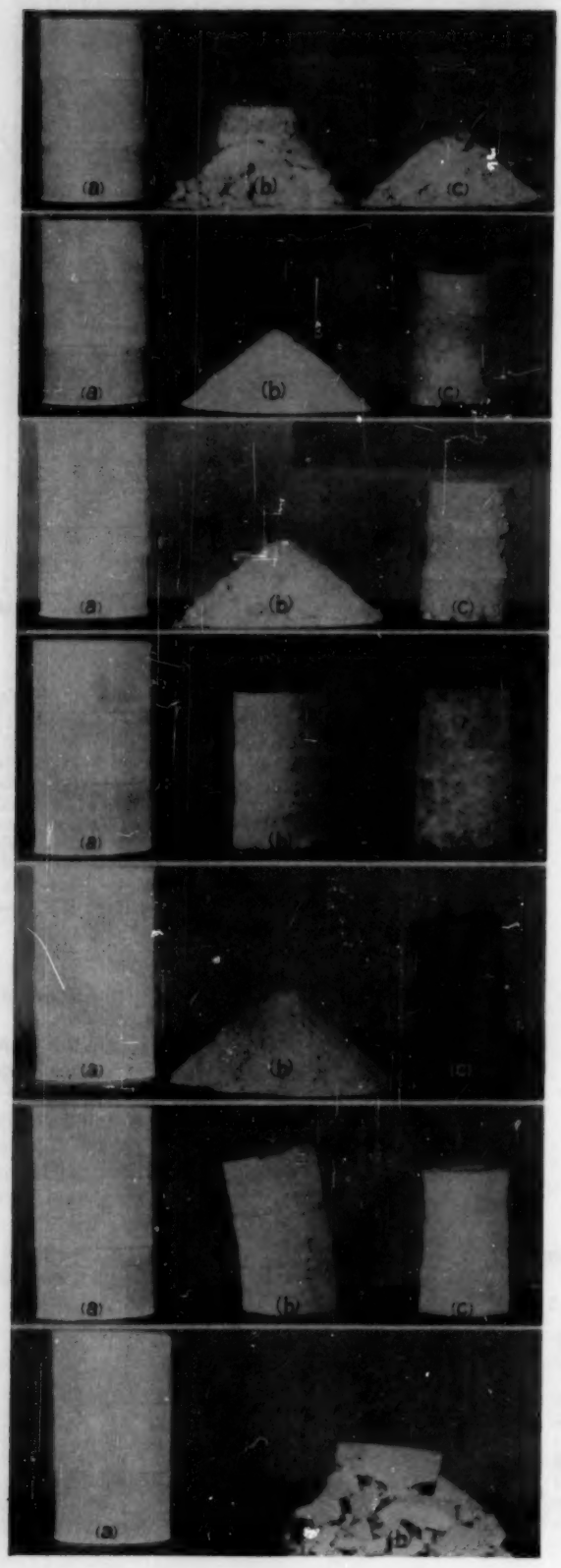


FIG. 12.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2300°F.: CaO 65.13% and SiO_2 34.87%.
(*c*) Chemical analysis of product fired at 2600°F.: CaO 64.80%, SiO_2 34.70%, and P_2O_5 0.50%.

FIG. 13.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2890°F.: CaO 65.13% and SiO_2 34.87%.
(*c*) Chemical analysis of fired product after firing at 2890°F.: CaO 64.80%, SiO_2 34.70%, and P_2O_5 0.50%.

FIG. 14.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3040°F.: CaO 65.13% and SiO_2 34.87%.
(*c*) Chemical analysis of product fired at 3040°F.: CaO 64.80%, SiO_2 34.70%, and P_2O_5 0.50%.

FIG. 15.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 64.80%, SiO_2 34.70%, and P_2O_5 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 64.48%, SiO_2 34.52%, and P_2O_5 1.00%.

FIG. 16.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 64.80%, SiO_2 34.70%, and Cr_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 64.48%, SiO_2 34.52%, and Cr_2O_3 1.00%.

FIG. 17.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 64.80%, SiO_2 34.70%, and B_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 64.48%, SiO_2 34.52%, and B_2O_3 1.00%.

FIG. 18.
CALCIUM ORTHOSILICATE ($2CaO \cdot SiO_2$) 50% AND PERICLASE 50%

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 32.40%, MgO 49.75%, SiO_2 17.35%, and P_2O_5 0.50%.

at 2890°F. Somewhere in this range there are critical temperatures, one of which is the lowest temperature at which P_2O_5 stabilizes calcium orthosilicate, and the second is the lowest temperature which yields a chemically inactive calcium orthosilicate. The first critical temperature indicates the physical stabilization of the calcium orthosilicate, and the second critical temperature indicates the chemical stabilization of the calcium orthosilicate.

Figure 16 shows that 0.5% of Cr_2O_3 does not stabilize calcium orthosilicate at 3020°F. but that 1.0% of Cr_2O_3 does effect stabilization. Chromium oxide, added to gamma-calcium orthosilicate, will stabilize it, but chrome ore added to pre-formed gamma-calcium orthosilicate does not stabilize it. If chrome ore is used, it must be added while there is free lime in the mixture so that the lime can decompose the chromite into calcium chromate, which stabilizes the calcium orthosilicate.

Figure 17 shows the effect of B_2O_3. As little as 0.5% causes severe warpage. The presence of boric acid may become dangerous in a formed refractory body.

TABLE VI

CALCIUM ORTHOSILICATE SERIES

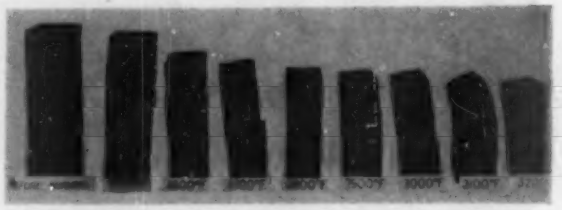
(2 moles of CaO:1 mole of SiO_2)

Figure No.	Additions (%)	Firing temp. (°F.)	Petrographic analysis (±10%)* (%) Calcium orthosilicate (alpha)	(gamma)	Periclase
15	None	2600	15	85	
15	0.5 P_2O_5	"	25	75	
16	None	2890	15	85	
16	0.5 P_2O_5	"	100		
17	None	3040	25	75	
17	0.5 P_2O_5	"	100		
18	0.5 P_2O_5	3020	50	50	
18	1.0 P_2O_5	"	75	25	
19	0.5 Cr_2O_3	"	50	50	
19	1.0 Cr_2O_3	"	75	25	
20	0.5 B_2O_3	"	60	40	
20	1.0 B_2O_3	"	60	40	
21	0.5 P_2O_5 50 MgO	"	50		50

* The petrographic analysis of pellets (Figs. 12 to 18, inclusive) was made on residual material in each case.

Figure 18 shows a pellet calculated to yield approximately equal quantities of periclase and calcium orthosilicate. This body contained 0.5% of P_2O_5 and was fired at 3020°F. It did not bond together although the calcium orthosilicate is stabilized. To make a properly bonded body, it is necessary for the composition to contain an appreciable amount of a low melting component.

Figure 19 is of interest to the industries which consider dolomite as a source of a new refractory material. The brick were made from exactly the same mix; note the effect of temperature on the residual shrinkage and on the chemical stability of the finished bodies. The brick fired at 3200°F. is chemically and physically stabilized.



Total hours of firing 14 17 20 23 26 29 32 35

FIG. 19.—Refractory brick containing periclase 25.3%, calcium orthosilicate 52.0%, monticellite 17.5%, and calcium phosphate (present). Raw mix: dolomite (fine-ground) 85.5%, silica (fine-ground) 14.5%, and phosphoric acid 1.0%. Chemical analysis of fired product: MgO 29.78%, CaO 40.18%, SiO_2 24.91%, Fe_2O_3 1.42%, Al_2O_3 2.76%, and P_2O_5 0.50%.

Table VII shows the chemical analyses and melting points of some of the bodies calculated to yield monticellite after firing at different temperatures. There was insufficient material left for the determination of the melting points in some cases.

Figure 20 shows that phosphoric acid has an appreciable effect on the rate of formation of monticellite but that the calcium orthosilicate is present in the gamma form when the monticellite decomposes at this temperature.

Figures 21 to 27, inclusive, show definitely that P_2O_5 causes the calcium orthosilicate to take the alpha form when the monticellite decomposes. Because a

TABLE VII

Refractory material	Formula	Chemical analysis CaO	MgO	SiO_2	P_2O_5	Cr_2O_3	B_2O_3	Firing temp (°F.)	Melting point (°F.)
100% monticellite	$CaO \cdot MgO \cdot SiO_2$	35.84	25.77	38.39				2600	
Calcium magnesium orthosilicate		35.66	25.64	38.20	0.50			2890	2500
								3040	
		35.66	25.64	38.20	0.50			3020	
		35.48	25.51	38.01	1.00				
		35.66	25.64	38.20		0.50		3020	
		35.48	25.51	38.01		1.00			
		35.66	25.64	38.20			0.50	3020	
		35.48	25.51	38.01			1.00		
50% monticellite 50% periclase	50% $CaO \cdot MgO \cdot SiO_2$ 50% MgO	17.83	62.57	19.10	0.50			3020	
25% monticellite 75% periclase	25% $CaO \cdot MgO \cdot SiO_2$ 75% MgO	8.92	81.03	9.55	0.50			3020	No fusion

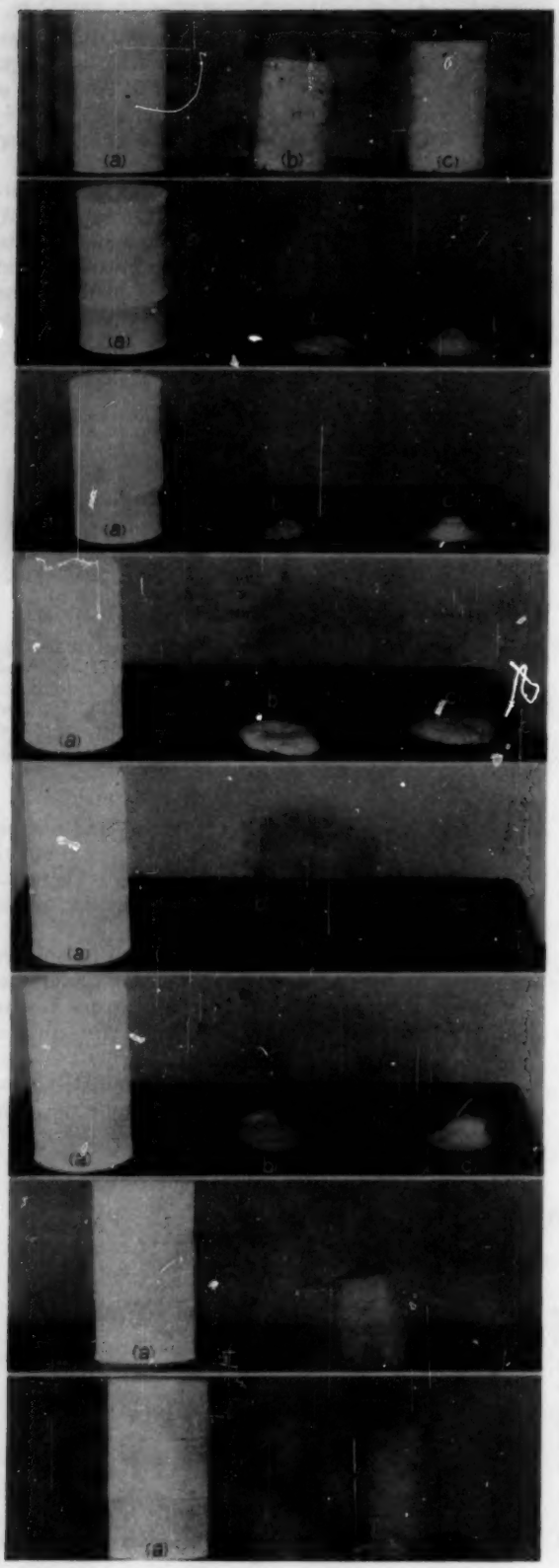


FIG. 20.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2600°F.: CaO 35.84%, MgO 25.77%, and SiO_2 38.39%.
(*c*) Chemical analysis of product fired at 2600°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and P_2O_5 0.50%.

FIG. 21.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2890°F.: CaO 35.84%, MgO 25.77%, and SiO_2 38.39%.
(*c*) Chemical analysis of product fired at 2890°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and P_2O_5 0.50%.

FIG. 22.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3040°F.: CaO 35.84%, MgO 25.77%, and SiO_2 38.39%.
(*c*) Chemical analysis of product fired at 3040°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and P_2O_5 0.50%.

FIG. 23.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and P_2O_5 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 35.48%, MgO 25.51%, SiO_2 38.01%, and P_2O_5 1.00%.

FIG. 24.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and Cr_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 35.48%, MgO 25.51%, SiO_2 38.01%, and Cr_2O_3 1.00%.

FIG. 25.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 35.66%, MgO 25.64%, SiO_2 38.20%, and B_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 35.48%, MgO 25.51%, SiO_2 38.01%, and B_2O_3 1.00%.

FIG. 26.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$) 50% AND PERICLASE 50%

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 17.83%, MgO 62.57%, SiO_2 19.10%, and P_2O_5 0.50%.

FIG. 27.
MONTICELLITE ($CaO \cdot MgO \cdot SiO_2$) 25% AND PERICLASE 75%

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 8.92%, MgO 81.03%, SiO_2 9.55%, and P_2O_5 0.50%.

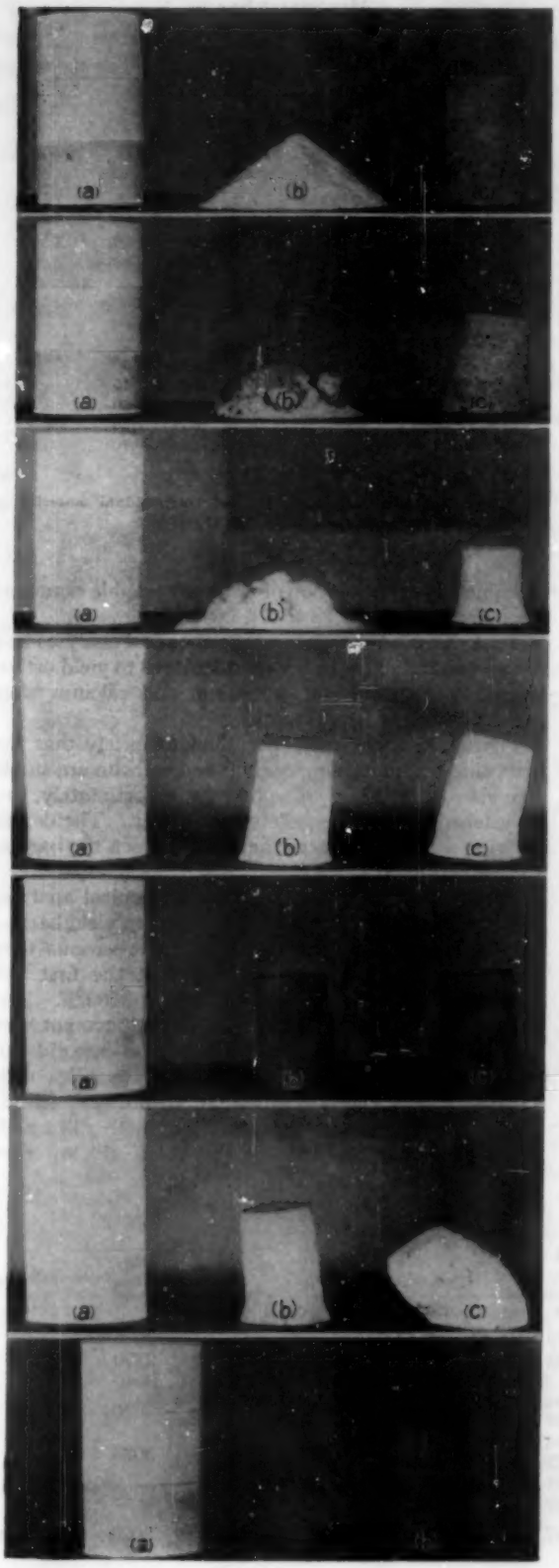


FIG. 28.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2600°F.: CaO 51.19%, MgO 12.27%, and SiO_2 36.54%.
(*c*) Chemical analysis of product fired at 2600°F.: CaO 50.93%, MgO 12.21%, SiO_2 36.36%, and P_2O_5 0.50%.

FIG. 29.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 2890°F.: CaO 51.19%, MgO 12.27%, and SiO_2 36.54%.
(*c*) Chemical analysis of product fired at 2890°F.: CaO 50.93%, MgO 12.21%, SiO_2 36.36%, and P_2O_5 0.50%.

FIG. 30.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3040°F.: CaO 51.19%, MgO 12.27%, and SiO_2 36.54%.
(*c*) Chemical analysis of product fired at 3040°F.: CaO 50.93%, MgO 12.21%, SiO_2 36.36%, and P_2O_5 0.50%.

FIG. 31.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 50.94%, MgO 12.20%, SiO_2 36.36%, and P_2O_5 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 50.67%, MgO 12.15%, SiO_2 36.18%, and P_2O_5 1.00%.

FIG. 32.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 50.94%, MgO 12.20%, SiO_2 36.36%, and Cr_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 50.67%, MgO 12.15%, SiO_2 36.18%, and Cr_2O_3 1.00%.

FIG. 33.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$)

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 50.94%, MgO 12.20%, SiO_2 36.36%, and B_2O_3 0.50%.
(*c*) Chemical analysis of product fired at 3020°F.: CaO 50.67%, MgO 12.15%, SiO_2 36.18%, and B_2O_3 1.00%.

FIG. 34.
MERWINITE ($3CaO \cdot MgO \cdot 2SiO_2$) 50% AND PERICLASE 50%

(*a*) Before firing.
(*b*) Chemical analysis of product fired at 3020°F.: CaO 25.47%, MgO 55.85%, SiO_2 18.18%, and P_2O_5 0.50%.

large portion of the monticellite has been absorbed by the pellet support in Figs. 20 to 25, the petrographic analyses cover only the residuals.

Figures 26 and 27 show the effect of periclase in bolstering monticellite.

TABLE VIII

MONTICELLITE SERIES

1 mole CaO:1 mole MgO:1 mole SiO_2

Figure No.	Additions (%)	Firing temp. (°F.)	Petrographic analysis (±10%)(%)* Monticellite	Periclase	Calcium orthosilicate (alpha)	Calcium orthosilicate (gamma)	Forsterite
20	None	2600	40			35	25
20	0.5 P_2O_5	"	40			35	25
21	None	2890		80	20		Trace
21	0.5 P_2O_5	"		70	30		"
22	None	3040		80	20		"
22	0.5 P_2O_5	"		70	30		"
23	0.5 P_2O_5	3020		70	30		"
23	1.0 P_2O_5	"		65	35		"
24	0.5 Cr_2O_3	"		70	30		"
24	1.0 Cr_2O_3	"		70	30		"
25	0.5 B_2O_3	"		70	30		"
25	1.0 B_2O_3	"		70	30		"
26	0.5 P_2O_5 50 MgO	"		85	15		"
27	0.5 P_2O_5 75 MgO	"		95	5		"

* The petrographic analysis was made on residual material in pellets shown in Figs. 21 to 27, inclusive(see p. 12).

Figures 28, 29, and 30 show that it is necessary to use stabilizers with mixtures of calcium to yield merwinite, although in no case has merwinite been found.

Figures 31, 32, and 33 show the effect of varying amounts of stabilizers on pellets of this group. This is another indication that merwinite is not present at temperatures above 2200°F. as it decomposes into calcium orthosilicate and into monticellite. The stabilizers do affect the calcium orthosilicate.

Figure 34 shows the effect of periclase as a bolstering agent and of P_2O_5 as a stabilizing agent on mixtures calculated to yield merwinite.

Table IX shows the chemical analyses and the melting points on a series of pellets containing the proper proportions of c.p. chemicals to yield merwinite after firing to various temperatures, with and without the addition of stabilizers.

TABLE X

MERWINITE SERIES

(3 moles of CaO:1 mole of MgO:2 moles of SiO_2)

Figure No.	Additions (%)	Firing temp. (°F.)	Petrographic analysis (±10%) (%)* Periclase	Calcium orthosilicate (alpha)	Calcium orthosilicate (gamma)	Forsterite
28	None	2600	10	45	45	Trace
28	0.5 P_2O_5	"	5	80	10	5
29	None	2890	10	60	30	Trace
29	0.5 P_2O_5	"	10	85	5	"
30	None	3040	10	60	30	"
30	0.5 P_2O_5	"	Trace	90	Trace	10
31	0.5 P_2O_5	3020	"	65	30	5
31	1.0 P_2O_5	"	"	75	20	5
32	0.5 Cr_2O_3	"		65	30	5
32	1.0 Cr_2O_3	"	Trace	80	15	5
33	0.5 B_2O_3	"	"	65	30	5
33	1.0 B_2O_3	"	"	65	30	5
34	0.5 P_2O_5 50 MgO	"	70	20	10	Trace

* The petrographic analysis was made on residual material in pellets (see Figs. 28 to 34, inclusive, p. 13).

Table X is a tabulation of the petrographic examinations shown in Figs. 28 to 34, inclusive.

Table XI is a tabulation of the chemical analyses and of the melting points of pellets calculated to yield orthosilicates of barium and of barium and calcium after firing at various temperatures.

Figures 35 to 38, inclusive, show definitely that the orthosilicates containing barium and calcium are stable (see also Table XII). The barium, unfortunately, can be leached from these pellets with water. The degree of firing simply influences the rate at which the barium can be extracted.

Table XIII is a tabulation of the chemical analyses and melting points of pellets calculated to yield barium magnesium orthosilicates after firing at various temperatures. The analyses indicate that the first two members of the group are not stable at 3100°F. Barium metasilicate was lost. The writers have not been able to find out how it was lost, but in no case did barium orthosilicate maintain its barium to silica ratio near 3100°F. The trimagnesium barium orthosilicate is not stable at 2876°F. as the barium to silica ratio changes appreciably even at this relatively low temperature.

TABLE IX

Refractory material	Formula	Chemical analysis CaO	MgO	SiO_2	P_2O_5	Cr_2O_3	B_2O_3	Firing temp. (°F.)	Melting point (°F.)
100% merwinite	$3CaO \cdot MgO \cdot 2SiO_2$	51.19	12.27	36.54				2600	
Magnesium tricalcium diorthosilicate		50.93	12.21	36.36	0.50			2890	3200
								3040	
		50.94	12.20	36.36	0.50			3020	3190
		50.67	12.15	36.18	1.00				3160
		50.94	12.20	36.36		0.50		3020	3160
		50.67	12.15	36.18		1.00			3180
		50.94	12.20	36.36			0.50	3020	3180
		50.67	12.15	36.18			1.00		3190
50% merwinite 50% periclase	50% $3CaO \cdot MgO \cdot 2SiO_2$ 50% MgO	25.47	55.85	18.18	0.50			3020	No fusion

Figures 39, 40, and 41 show the effects of varying temperatures on the pellets of this group.

Table XIV is a tabulation of the petrographic examinations of the pellets shown in Figs. 39, 40, and 41.

Table XV is a tabulation covering fired mixtures calculated to yield complex orthosilicates containing barium, calcium, and magnesium. The calcined barium-calcium-dimagnesium orthosilicate mixture melts below cone 16. The melting points of the

TABLE XI

Orthosilicates of barium		Calculated		Fired at cone 16 (2642°F., 1450°C.) actual			Fired at cone 23 (2876°F., 1580°C.) actual			Fired at cone 32 (3092°F., 1700°C.) actual		
		Mole ratio	Chemical analysis	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)
$2BaO \cdot SiO_2$	BaO	2	83.63	2	83.05		2	82.50		2	82.53	
	CaO					3200			3170			3160
	MgO											
	SiO_2	1	16.37	1	15.95		1	15.66		1	17.32	
$BaO \cdot CaO \cdot SiO_2$	BaO	1	56.90	1	57.77		1	56.58		1	57.82	
	CaO	1	20.81	1	20.03		1	20.04		1	19.60	
	MgO					3160			3150			3150
	SiO_2	1	22.29	1	21.31		1	21.36		1	21.42	
$3BaO \cdot CaO \cdot 2SiO_2$	BaO	3	72.31	3	70.86		3	72.18		3	72.06	
	CaO	1	8.81	1	8.24		1	8.43		1	8.33	
	MgO					3040			3200			3200
	SiO_2	2	18.88	2	18.22		3	18.55		2	18.52	
$BaO \cdot 3CaO \cdot 2SiO_2$	BaO	1	34.72	1	35.54		1	35.00		1	36.51	
	CaO	3	38.09	3	35.90		3	36.79		3	35.95	
	MgO					3070			3100			3120
	SiO_2	2	27.19	2	26.30		2	26.72		2	26.60	

TABLE XII

ORTHOSILICATES OF BARIUM AND OF BARIUM AND CALCIUM*

Reacting materials to yield	Figure No.	Firing temp. (°F.)	
$2BaO \cdot SiO_2$	35	2642	100% barium orthosilicate
"	35	2876	" " "
"	35	3092	" " "
$BaO \cdot CaO \cdot SiO_2$	36	2642	Probably $BaO \cdot CaO \cdot SiO_2$
"	36	2876	" "
"	36	3092	" "
$3BaO \cdot CaO \cdot 2SiO_2$	37	2642	" $3BaO \cdot CaO \cdot 2SiO_2$
"	37	2876	" $2BaO \cdot SiO_2$ and $BaO \cdot CaO \cdot SiO_2$
"	37	3092	" " " "
$BaO \cdot 3CaO \cdot 2SiO_2$	38	2642	" $2CaO \cdot SiO_2$ and $BaO \cdot CaO \cdot SiO_2$
"	38	2876	" " " "
"	38	3092	" " " "

* The petrographic analysis was made on residual material in Figs. 35 to 38, inclusive (see p. 16); nothing has been published on these complex orthosilicates.

TABLE XIII

Orthosilicates of barium		Calculated		Fired at cone 16 (2642°F., 1450°C.) actual			Fired at cone 23 (2876°F., 1580°C.) actual			Fired at cone 32 (3092°F., 1700°C.) actual		
		Mole ratio	Chemical analysis	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)
$BaO \cdot MgO \cdot SiO_2$	BaO	1	60.44	1	58.78		1	58.45		1	21.43	
	CaO					2780			2840			No fusion
	MgO	1	15.89	1	15.60		1	15.74		12	69.59	
	SiO_2	1	23.67	1	23.28		1	23.25		3	8.36	
$3BaO \cdot MgO \cdot 2SiO_2$	BaO	3	74.14	3	72.26		3	72.69		5	77.88	
	CaO					3180			3100			2980
	MgO	1	6.50	1	6.32		1	6.50		1	4.04	
	SiO_2	2	19.36	2	18.53		2	18.88		3	16.50	
$BaO \cdot 3MgO \cdot 2SiO_2$	BaO	1	38.88	1	39.40		1	16.57		1	7.25	
	CaO					2680			3250			3250
	MgO	3	30.67	3	30.29		13	56.03		36	69.43	
	SiO_2	2	30.45	2	30.04		4	25.92		8	22.18	

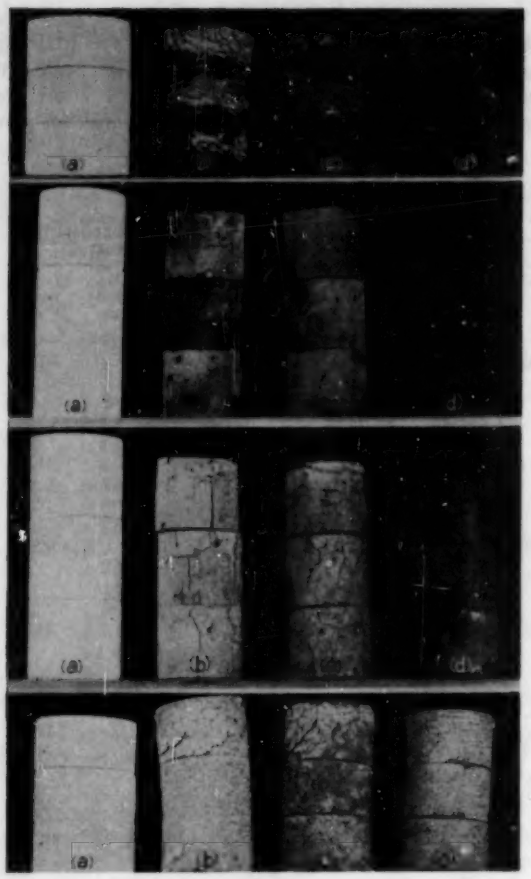


FIG. 35.
$2BaO \cdot SiO_2$
83.63% 16.37%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 36.
$BaO \cdot CaO \cdot SiO_2$
56.90% 20.81% 22.29%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 37.
$3BaO \cdot CaO \cdot 2SiO_2$
72.31% 8.81% 18.88%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 38.
$BaO \cdot 3CaO \cdot 2SiO_2$
34.72% 38.09% 27.19%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

TABLE XIV

ORTHOSILICATES OF BARIUM AND MAGNESIUM*

Reacting materials to yield	Figure No.	Firing temp. (°F.)	
$BaO \cdot MgO \cdot SiO_2$	39	2642	Partially devitrified glass; probably $BaO \cdot MgO \cdot SiO_2$
"	39	2876	" " " " "
"	39	3092	Periclase in glass
$3BaO \cdot MgO \cdot 2SiO_2$	40	2642	$2BaO \cdot SiO_2$ in partially devitrified glass
"	40	2876	" " " " "
"	40	3092	" " " " "
$BaO \cdot 3MgO \cdot 2SiO_2$	41	2642	Barium metasilicate and periclase
"	41	2876	" " " "
"	41	3092	" " " "

* The petrographic analysis was made on residual material shown in Figs. 39 to 41, inclusive; nothing has been published on these complex orthosilicates.

barium-magnesium-dicalcium orthosilicate mixtures vary from 2560° to 3260°F., depending on the temperature at which the mixtures were originally fired. The calcium-magnesium-dibarium orthosilicate is not stable at 2876°F. as its chemical composition has changed, particularly in the ratio of barium to silica.

Table XVI is a tabulation of analytical data on two mixes in which barium orthosilicate was formed as a bond for magnesite brick. In no case has the BaO to SiO_2 ratio been maintained on the first firing. On reheating at cone 33, the barium to silica ratio increases gradually. The increase is much more rapid and pronounced in the presence of Fe_2O_3. Brick No. 62 shows an interesting trend when a periclase brick, bonded with barium orthosilicate, is reheated.

Table XVII is a tabulation of the petrographic examinations of the pellets shown in Figs. 42, 43, and 44.

III. Conclusions

Magnesium orthosilicate is the most satisfactory high-temperature alkaline earth orthosilicate because (1) it is physically stable; (2) it is chemically inactive; (3) it does not form other compounds with an excess

TABLE XV

Orthosilicates of barium		Calculated		Fired at cone 16 (2642°F., 1450°C.) actual			Fired at cone 23 (2876°F., 1580°C.) actual			Fired at cone 32 (3092°F., 1700°C.) actual		
		Mole ratio	Chemical analysis	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)	Mole ratio	Chemical analysis	Melting point (°F.)
$BaO \cdot CaO \cdot 2MgO \cdot 2SiO_2$	BaO	1	37.39									
	CaO	1	13.67									
	MgO	2	19.66	*	*	3250	*	*	*	*	*	*
	SiO_2	2	29.28									
$BaO \cdot 2CaO \cdot MgO \cdot 2SiO_2$	BaO	1	36.00	1	35.41		1	34.93		1	33.52	
	CaO	2	26.33	2	24.55		2	26.26		2	31.25	
	MgO	1	9.47	1	9.75	2860	1	10.10	2560	1	10.18	3260
	SiO_2	2	28.20	2	26.80		2	27.82		2	25.20	
$2BaO \cdot CaO \cdot MgO \cdot 2SiO_2$	BaO	2	58.62	2	56.99		2.5	63.36		2.5	65.00	
	CaO	1	10.72	1	9.95		1	8.90		1	8.74	
	MgO	1	7.70	1.	6.84	3200	1	6.85	3170	1	6.08	3170
	SiO_2	2	22.96	2	21.85		2	20.40		2	19.62	

* Insufficient residual material for chemical analysis.

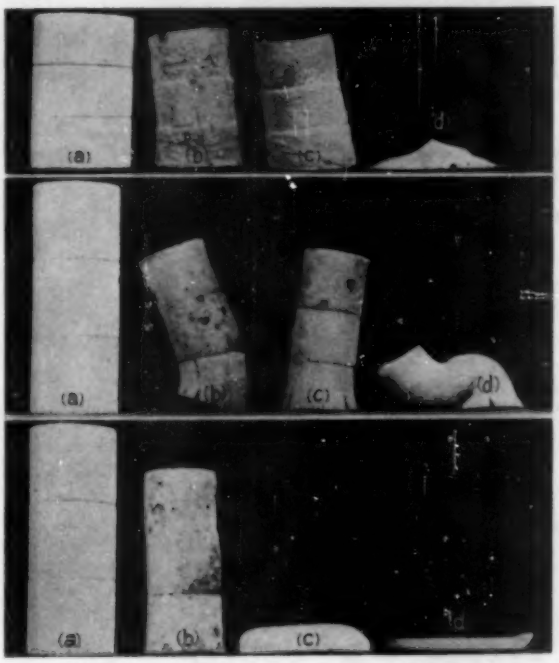


FIG. 39.
$BaO \cdot MgO \cdot SiO_2$
60.44% 15.89% 23.67%

(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 40.
$3BaO \cdot MgO \cdot 2SiO_2$
74.14% 6.50% 19.36%

(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 41.
$BaO \cdot 3MgO \cdot 2SiO_2$
38.88% 30.67% 30.45%

(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

of magnesia; (4) it can be formed from the periclase which it is used to bond; (5) it is bolstered by magnesia in respect to melting point, chemical activity, and chemical and physical stability; (6) the presence of periclase increases the rate of formation and degree of formation of forsterite; (7) it dilutes monticellite and minimizes the deleterious effects of monticellite; (8) it is formed from other magnesium silicates when periclase is added, as in physically and chemically corrected chrome brick; and (9) it is stable within limits of Al_2O_3 and Fe_2O_3.

The disadvantages of forsterite are (1) MgO is replaced by CaO, SrO, and BaO, yielding low-melting point or unstable orthosilicates and (2) the formation of forsterite is partially inhibited by P_2O_5, B_2O_3, and Cr_2O_3.

Calcium orthosilicate is next in importance because (1) it has the highest melting point of the group; (2) it can be stabilized physically; (3) it can be stabilized chemically; (4) it does not react with MgO; (5) its softening point can be controlled with monticellite; and (6) it is fairly stable in the presence of limited quantities of Al_2O_3 and Fe_2O_3.

Monticellite is a useful component of refractories because (1) it forms a liquid phase which increases the rate of formation of both forsterite and calcium orthosilicate and (2) it acts as a bond in the presence of the high-melting point orthosilicate of CaO and MgO. It becomes troublesome when it is not associated with periclase and the calcium and magnesium orthosilicates because of its lack of chemical and physical stability.

Merwinite is so unstable at relatively low temperatures that it cannot be considered in this field.

TABLE XVI

CHEMICAL ANALYSES OF BARIUM ORTHOSILICATE BONDED MAGNESITE BRICK

Description of sample	Brick No. 61: 100 parts No. 2662 magnesite, FF-grind; 2.26 parts tripoli, FF-grind; 18.06 parts barytes, FF-grind								Brick No. 62: 100 parts No. 2662 magnesite, FF-grind; 3.29 parts tripoli, FF-grind; 26.59 parts barytes, FF-grind							
	BaO	CaO	SiO_2	MgO	Fe_2O_3	Al_2O_3	SO_3	Molecular ratio $\frac{BaO + CaO}{SiO_2}$	BaO	CaO	SiO_2	MgO	Fe_2O_3	Al_2O_3	SO_3	Molecular ratio $\frac{BaO + CaO}{SiO_2}$
Original mix (before firing)	10.59	1.30	3.44	76.52	0.68	0.71	6.32	1.6075	14.70	0.97	5.37	70.48	0.42	0.42	8.50	1.6798
Original clinker (cone 33)	11.00	1.18	3.21	83.34	0.52	0.18	0.27	1.7359	15.28	1.09	3.78	78.14	0.48	0.16	0.76	1.8918
Composite sample of proportioned grind brick No. 62 (cone 26)									15.35	1.21	3.93		0.80	0.47	1.00	1.8577
Corners of proportioned grind brick No. 62 (cone 26)									15.28	1.15	3.92		0.60	0.70	0.58	1.8420
	100 parts No. 61 clinker with 3.64 parts barytes															
Reground No. 61 clinker and additional barytes (before firing)	13.09	0.95	3.08	80.02	0.57	0.29	1.63	1.9920								
Reground No. 61 clinker and additional barytes (cone 33)	12.81	1.24	3.42		0.88	0.65	2.10	1.8558								
Corners of reground and refired No. 61 clinker (cone 33)	11.86	1.71	3.13		0.96	0.93	1.93	2.0671								
No. 1 refire (cone 33)	11.66	1.75	2.60		1.04	0.55	0.87	2.4757	15.30	1.19	3.95		0.91	0.56	0.39	1.8401
No. 2 " " "	10.99	1.18	2.79		0.76	0.40	0.02	1.9956	15.38	1.31	3.92		0.84	0.91	0.23	1.8941
No. 3 " " "	9.92	1.45	2.64		0.76	0.50	0.05	2.0592	15.20	1.06	3.66		0.80	0.65	0.17	1.9376
No. 4 " " "	11.53	1.90	2.41		1.15	0.49	0.00	2.7157	14.43	1.28	3.50		0.80	0.83	0.15	2.0068
No. 5 " " "	11.58	1.83	2.40		1.10	0.40	0.00	2.7092	14.20	1.54	3.46		0.40	0.46	0.07	2.0798
No. 6 " " "									13.22	1.47	3.00		0.64	0.63	0.05	2.2525
No. 7 " " "									12.79	1.69	3.23		1.07	0.17	0.00	2.1135
Centers of brick fired repeatedly at cone 33	11.66	2.03	2.50		0.92	0.21	0.00	2.6947	13.57	1.87	3.00		0.72	0.39	0.00	2.4388
	Brick No. 61 containing 8% of Fe_2O_3															
Before firing	10.68	1.37	3.31		8.04	1.31	0.18	1.7059								
Fired at cone 33	9.51	1.24	2.80		7.98	0.52	0.10	1.8047								
No.1 refire (cone 33)	7.43	1.26	2.04		7.47	0.94	0.03	2.0884								
No. 2 " " "	5.92	1.17	1.51		7.78	0.16	0.00	2.3665								
No. 3 " " "	5.74	1.30	1.49		7.14	0.34	0.00	2.4395								
Centers of brick fired repeatedly at cone 33	7.17	1.39	2.17		7.26	0.59	0.00	2.0341								

FIG. 42.
$BaO \cdot CaO \cdot 2MgO \cdot 2SiO_2$
37.39% 13.67% 19.66% 29.28%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2676°F.–1580°C.).
(*d*) After firing at cone 32 (30.92°F.–1700°C.).

FIG. 43.
$BaO \cdot 2CaO \cdot MgO \cdot 2SiO_2$
36.00% 26.33% 9.47% 28.20%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

FIG. 44.
$2BaO \cdot CaO \cdot MgO \cdot 2SiO_2$
58.62% 10.72% 7.70% 22.96%
(*a*) Before firing.
(*b*) After firing at cone 16 (2642°F.–1450°C.).
(*c*) After firing at cone 23 (2876°F.–1580°C.).
(*d*) After firing at cone 32 (3092°F.–1700°C.).

TABLE XVII

COMPLEX ORTHOSILICATES OF BARIUM, CALCIUM AND MAGNESIUM*

Reacting materials to yield	Figure No.	Firing temp. (°F.)	
$BaO \cdot CaO \cdot 2MgO \cdot 2SiO_2$	42	2642	Insufficient residual material for petrographic examination
"	42	2876	
"	42	3092	
$BaO \cdot 2CaO \cdot MgO \cdot 2SiO_2$	43	2642	Around 2900°F., barium orthosilicate reverts to barium metasilicate and liberates MgO
"	43	2876	
"	43	3092	
$2BaO \cdot CaO \cdot MgO \cdot 2SiO_2$	44	2642	Devitrified glass
"	44	2876	" "
"	44	3092	" "

* The petrographic analysis was made on residual material shown in Figs. 42, 43, and 44; nothing has been published on these complex orthosilicates.

At temperatures as low as 2300°F., it cannot exist under any of the conditions which have been explored.

Barium and strontium orthosilicates are not very satisfactory for higher temperature refractory use because (1) they are too fusible; (2) they may form very fusible compounds with magnesium orthosilicates; and (3) they decompose in the presence of water and steam. They are satisfactory in the lower temperature field because (1) they are not replaced by MgO and CaO and (2) they do not react with magnesium and calcium orthosilicates at lower temperatures.

Compound and complex orthosilicates of the alkaline earths are fugitive. They exist under one condition but transpose under others. Care is required in the preparation of reference specimens. Slight changes in temperature ranges cause great changes in chemical rearrangement and physical conditions. More work is indicated in this field.

(1941)

The study of the orthosilicates of the alkaline earths in the high-temperature refractory field has led to the following conclusions: (1) There is a critical temperature below which an orthosilicate of the alkaline earths does not form chemically; (2) there is a critical temperature higher than the foregoing, below which an orthosilicate of the alkaline earths cannot be physically stabilized; (3) there is a critical temperature higher than (1) or (2), below which a stabilized orthosilicate of the alkaline earths cannot be made chemically inactive; (4) there is a marked difference between substantially homogeneous mixtures of orthosilicates and mixtures of orthosilicates wherein, instead of relative homogeneity, there exist carefully controlled relative placements of one orthosilicate to another or relative placement of orthosilicates to crystallized oxides of the alkaline earths; (5) the deleterious effect of a low-melting point orthosilicate of this group can be minimized by dilution into a relatively large amount of another orthosilicate with which it does not react but which has desirable properties and characteristics; (6) the rate of reaction by which orthosilicates of this group can be formed is controllable by a careful choice of raw materials from which the orthosilicates are to be formed; (7) the rigidity of a body during the formation of the orthosilicates is controllable by a careful choice of the raw materials from which the orthosilicates are formed; and (8) there is a definite and controllable advantage in causing a reaction to take place such that the surfaces of the refractory grains are one of the reacting materials which form orthosilicates so that thin films of the product of reaction completely surround each grain and the interstitial product of reaction originates partly from the surfaces of the two adjacent grains with the additive reagents surrounding the grains.

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DISCUSSION OF SEIL PAPER BY HARLEY C. LEE

Minerals are seldom pure chemical compounds as they occur in nature, and their composition usually depends on their chemical environment during crystal growth as well as on the heat treatment during this period. Most minerals tend to take other materials into solid solution at high temperatures. At lower temperatures, these substances ordinarily cre retained in solid solution or they are precipitated in part as inclusions in the mineral. These so-called impurities in minerals have pronounced effects on refractory properties, such as melting and fluxing characteristics, dissociation and inversion temperatures, and density and stability.

The orthosilicates found in nature are rarely of high purity. Olivine, which is a noteworthy example, is probably the most commonly occurring of the orthosilicates, and it is found in many different environments, ranging from basic peridotites and dunites to acidic rocks. Its composition and properties depend on the temperature of its formation and the amount and kind of impurities characterizing the rock in which it was formed. Bowen and Schairer[1] have ably shown how the composition and melting temperature of olivine in the system MgO–FeO–SiO_2 changes continuously by solid solution from forsterite, with a melting temperature of 1890°C., to fayalite, which melts at 1205°C.

Because of the marked influence of small amounts of impurities on the melting characteristics and thermochemical properties of minerals, the Geophysical Laboratory was compelled to use exceptionally pure raw materials and extraordinary precautions to prevent the contamination of these materials when they determined the equilibria and melting characteristics of the minerals in silicate systems. The orthosilicates of the alkaline earth metals have a proclivity to form solid solutions with a great many different substances. Seil has indicated that the presence of slight amounts of impurities are factors affecting the properties of bodies containing alkaline earth orthosilicates, and he has also mentioned that the orthosilicates of the alkaline earth metals have varying properties, which depend on the starting materials and on the temperatures of formation.

Solid solutions of the orthosilicates are commonly encountered in refractory products, and the variability in the orthosilicates is not limited to the manufactured refractories but is even more pronounced after the refractories have been in service. The writer has been interested principally in following refractories in service and in studying the changes that occur. The refractory orthosilicates reach equilibrium very slowly, even when they are heated to high temperatures. Refractories, therefore, do not usually attain equilibrium in an ordinary manufacturing process (which may seem to yield a doubtful value to phase-equilibrium studies). After long-continued service at high temperatures, however, the refractory is brought much closer to equilibrium. Complete knowledge of the phase relationships then becomes extremely useful in interpreting what has happened to the refractory in service. Because of the complexity of conditions and the increase in the number of components present, oftentimes too little is known about the true equilibrium. The original properties and melting characteristics of the orthosilicates in the refractory are not fixed, but they may vary, depending on the composition of the original refractory and also on the composition and temperature of the environment to which the refractory is exposed. Such change in mineral composition and properties of a refractory body is in agreement with Bowen's reaction principle,[2] which shows that a change in environment (either in temperature or in the composition of the system) may bring about a change in the composition of the minerals or even the formation of new minerals by reaction between the phases previously in equilibrium. Bowen[2] has also shown that minerals having reaction relationships may be present in amounts and of compositions which vary from calculated molecular proportions.

Numerous solid solutions of calcium orthosilicate may be cited. Greer[4] has indicated that calcium orthosilicate forms a solid solution with manganese orthosilicate. Phillips[5] has shown that calcium orthosilicate can dissolve limited amounts of chromium oxide in solid solution and also may possibly dissolve small amounts of iron oxide, aluminum oxide, and magnesium oxide. McCaughey[6] has shown that calcium orthosilicate can form a solid solution with calcium phosphate. Bowen, Schairer, and Posnjak[7] have shown that calcium orthosilicate takes up fayalite (Fe_2SiO_4) in solid solution.

Variations of the foregoing solid solutions are sometimes encountered in dolomite refractories sampled during the course of an open-hearth heat. The composition and properties of dicalcium silicate in contact with open-hearth slag depend principally on the temperature and the composition of the liquid part of the slag. The dicalcium silicate in contact with the early slag frequently has indices of refraction as low as 1.69, a much lower birefringence than is found normally, and it is nearly uniaxial in character. Dicalcium silicate, with these properties, is characterized by having calcium phosphate in solid solution. Later in the heat, the dicalcium silicate, which develops reaction rims, is usually of higher index and higher birefrigence and has less calcium phosphate in solid solution.

When calcium orthosilicate is in contact with slags high in iron oxide and manganese oxide, the calcium orthosilicate becomes brown in color and apparently takes up iron oxide and manganese oxide in solid solution. Similar brown calcium orthosilicate is also observed in Portland

[1] N. L. Bowen and J. F. Schairer, "System MgO–FeO–SiO_2," *Amer. Jour. Sci.*, **29**, 151–217 (1935); *Ceram. Abs.*, **15** [9] 288 (1936).

[2] N. L. Bowen, Evolution of Igneous Rocks, pp. 54–62. Princeton Univ. Press, 1928; *Ceram. Abs.*, **8** [8] 609 (1929).

[3] *Ibid.*, pp. 70–71.

[4] W. L. C. Greer, "Mix-Crystals of Ca_2SiO_4 and Mn_2SiO_4," *Amer. Mineralogist*, **17**, 135 (1932).

[5] J. G. Phillips, "Determination of Some Mineral Phases Developed in Canadian Magnesitic Dolomite Refractories." Thesis, Ohio State University, 1938.

[6] W. J. McCaughey, "Discussion on Open-Hearth Slags," *Minutes of 12th Semi-Annual Conf., Amer. Inst. Mining Met. Engrs., Open-Hearth Comm.*, pp. 73–74 (1930).

[7] N. L. Bowen, J. F. Schairer, and E. Posnjak, "System Ca_2SiO_4–Fe_2SiO_4," *Amer. Jour. Sci.*, **25**, 273–97 (1933).

cement clinkers. When there is a considerable amount of chromium oxide in the slag, the calcium orthosilicate in contact with the slag usually is colored a deep green and apparently has taken up chromium oxide in solid solution.

In its high-temperature modifications, calcium orthosilicate has a propensity to form solid solutions with a great many minerals. The fact that calcium orthosilicate can dissolve in solid solution oxides of boron, phosphorus, and chromium probably accounts for the reason that calcium orthosilicate can be stabilized in its high-temperature form by these materials.

Monticellite has also been shown to form limited and extensive solid solutions with numerous other compatible minerals. In their work on the ternary system, CaO–MgO–SiO_2, Ferguson and Merwin[8] showed that monticellite takes forsterite into solid solution.

Schoenlaub[9] has shown that there is a continuous series of solid solutions between monticellite, glaucochroite, and calcium fayalite. Belyankin's[10] work has confirmed the monticellite-calcium fayalite solid solution series. Schoenlaub also showed that these silicates take up a limited amount of calcium phosphate in solid solution. The effect of added glaucochroite and calcium fayalite on the monticellite solid solution is to lower, progressively, the melting temperature of the monticellite.

Bowen, Schairer, and Posnjak[7] have shown that the calcium-iron-orthosilicate forms a continuous solid solution with fayalite as well as a solid solution with dicalcium silicate. They have also shown that the pure calcium-iron-monticellite melts at 1208°C., whereas the solid solution containing additional Fe_2SiO_4 melts at 1117°C.

In the examination of refractories that have been in service, pure monticellite is seldom encountered; ordinarily it is modified to a greater or less degree by solid solution of other minerals.

Seil has pointed out how forsterite varies in character in the processed refractory. The writer has frequently found still further changes in this mineral after refractories containing it have been in high-temperature service. The orthosilicates of the chrysolite type are commonly found in slags and refractories as well as in natural rocks.

Solid solutions of orthosilicates are sometimes encountered which cannot be accurately identified. Where there are no accurate optical and physical data to fit a given phase, a similar solid solution is synthesized. By such procedure, the orthosilicates are found to form solid solutions much more generally than the literature indicates. Because some of these solid solutions enhance the usefulness of the orthosilicate as refractory constituents whereas others impair the refractory qualities, it is important to understand and consider the extent and character of these solid solutions, particularly as they affect the refractory service.

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[8] J. B. Ferguson and H. E. Merwin, "VII, Ternary System CaO–MgO–SiO_2," *Amer. Jour. Sci.*, [4] **48**, 81–123 (1919).

[9] R. A. Schoenlaub, "Equilibrium Studies in System Monticellite-Glaucochroite-Calcium Fayalite." Doctor's dissertation, Ohio State Univ., 1933.

[10] D. S. Belyankin, K. M. Feodot'ev, and C. S. Nikogosyan, "Experimental Investigation of Magnesium Iron-Bearing Monticellites," *Neues Jahrb. Mineral. Geol.*, **68A**, 337–47 (1934); *Ceram. Abs.*, **15** [1] 38 (1936).

DISCUSSION OF SEIL PAPER BY MAX Y. SEATON

Seil's paper goes far beyond its title, for in addition to specific discussions of orthosilicates, it touches on certain fundamental principles which must be followed in the formulation of commercially important basic refractories. Both the general and the patent literature indicate that workers in this field have been too generally accustomed to rely on formulas as expressions of quality. The placement of constituents within the finished refractory as Seil has suggested is of equally vital importance. This is the first instance to the writer's knowledge where the effect of orthosilicate stabilizers on the reaction rate of orthosilicate formation has been discussed and the importance of such influences shown.

It is not so long ago that the steelmaker used a basic refractory only as a last resort. He expected his magnesite and chrome brick to be weak, only roughly true to specified dimensions, extremely poorly resistant to spalling, and incapable of bearing any substantial load at high temperatures. Even basic slags penetrated them readily, and the more acid fluxes eroded them rapidly. The past ten or fifteen years—indeed, even the last five years—have seen relatively enormous advances in basic refractory quality. The completely basic open-hearth furnace is already in sight. Experimental furnaces of this type have attained temperatures which, translated to commercial units, should show production rates and control of quality of steel beyond any practice now known. The basic refractories of twenty years ago would stand little chance in a roof arch or under the severe mechanical and thermal conditions which a rotary kiln lining must meet. Present-day successes in these fields have come from the application of the general principles which Seil suggests.

Seil's choice of magnesium orthosilicate as the preferred refractory material among the orthosilicates seems inescapable. If no other reason presented itself, the fact that, with this compound, an excess of the basic oxide can be present without harm to refractory performance, indeed with actual benefit, would be a determining factor in this choice. Substantial excesses of free calcium, strontium, or barium oxide in a refractory body are definitely detrimental. If orthosilicates of these elements are to be used, they must be employed without large admixture of their corresponding basic oxide. With such an oxide-free product in contact with metallurgical slags, a condition somewhat similar to that occurring with unbuffered inorganic solutions exists, that is, the pure orthosilicate, like the unbuffered solution, changes its properties radically when acid or base reacts with it. With magnesium ortho-

silicates, large excesses of free magnesium oxide are possible or even desirable, and the resulting refractory, "buffered" by the presence of this material, is far less susceptible to violent alteration in properties when contacted with slags.

Seil expresses uncertainty as to how iron and aluminum oxides, present in minor amounts in refractories which contain major amounts of orthosilicates, are really combined at high temperatures, and the writer shares this uncertainty. If the field be limited to that in which alumina is present in magnesium or calcium orthosilicates, which also contain an excess of magnesia, it is believed that quite specific statements as to the type and properties of the compounds present can be made, for data on this particular quaternary system have been collected. Bring barium and strontium into the picture and no specific facts are available. The uncertainties which exist regarding the functioning of iron oxide in such systems are even greater than for alumina. In the magnesium–calcium–orthosilicate excess magnesia system, small amounts of iron seem to exert but little influence on the high-temperature properties of the refractory. The influence of iron compounds in the intermediate temperature range in such a system, however, is very great indeed because the presence of such compounds radically influences the firing characteristics of both the grain and the shapes, the heat-setting characteristics of the grain, and the spalling resistance of the shapes. No clear-cut explanation of the mechanism behind such phenomena has yet been suggested. The reality of the phenomena, however, is becoming generally recognized, and the important place in industrial refractories which low-iron magnesias hold is being correspondingly emphasized.

The apparent instability of barium orthosilicate at high temperatures, mentioned by Seil, is another puzzling phenomenon. Just why this breakdown should occur in the presence of only minor amounts of other compounds (but with an excess of free magnesia present) cannot readily be explained. This breakdown and its great acceleration in the presence of iron compounds must be understood and controlled before wide use of barium orthosilicates in the high-temperature refractory field will be possible. Their use at lower temperatures, however, may well hold elements of real interest. For economic reasons, the barium and the strontium compounds obviously must exhibit markedly superior properties to calcium and magnesium compounds to warrant their use.

Seil has suggested briefly the various alternatives which present themselves to producers of orthosilicate-containing grain materials intended for furnace-bottom maintenance. It is in this class of materials that the substantial though ill-understood influence of iron oxide in orthosilicate bodies can well be used to advantage. In such materials, too, the use of exactly regulated minor amounts of alumina is important to adjust the amount of molten (although very viscous) material present at furnace temperatures and so regulate the toughness and other properties of the monolithic bottom. The mixture of a low-melting orthosilicate with a constituent which will react with it with a following sharp increase in melting point,[1] represents an interesting and possibly important technique in this particular field. This is an exemplification of the "two-stage" principle, which is useful also in the preparation of formed refractory shapes. In its use, a clinker or grog containing a low-melting orthosilicate, monticellite for example, is mixed with stoichiometric quantities of proper base (calcium oxide in this case) formed into shapes and fired. Reaction goes on at high temperatures with the formation of the very refractory calcium orthosilicate, and at the same time desirable body structures are obtainable which cannot be secured if the original clinker contains predominantly this compound. The importance of the placement of refractory constituents is illustrated in such a procedure as this for, although the chemical composition of a shape made by the "two-stage" process may be no different from that of one made from a grain in which reaction to calcium orthosilicate has been completed, the former brick is definitely superior structurally to the latter. This is true primarily because a dense, large-crystal periclase-in-calcium-orthosilicate grog cannot be made within the temperature limitations of fuel-fired furnaces unless objectionable amounts of fluxing impurities are introduced, whereas a dense, pure, monticellite-bonded grog is readily producible.

As Seil has indicated, phase-rule diagrams are only a part, probably a relatively unimportant part, of the data on which orthosilicate-containing basic-refractory formulation must be based. Such diagrams are of substantially greater importance in the development and production of the clinker or grog from which the final shapes are fabricated. When the raw materials used in refractories in this field originated solely from natural ores, such diagrams were of somewhat academic interest, for rarely could ore composition be selected to lie consistently in a preferred phase-rule field. With the increasing use of basic raw materials, however, originating from accurately controllable precipitation or similar processes, knowledge of the compounds present and the solubility relationships existing at relatively high temperatures in these rather complex systems has become vital if the composition of the ultimate raw material from which clinker is to be produced is to be properly adjusted. The research staff of the organization with which the writer is connected thus found it necessary to prepare the diagram of the quaternary system lime–silica–alumina–magnesia-in-excess in order to interpret intelligently the phenomena observed during the preparation of a refractory clinker from the relatively pure magnesium hydroxide precipitated from sea-water bittern. The phase-rule data have proved to be of major importance in such clinker manufacture. This is no contradiction of Seil's comments as to the lesser importance of such data in the formed-refractory field. It is rather a further confirmation of his implied comments as to the immense complexity of the field as a whole.

It is believed that Seil has performed a real service in outlining the fundamentals which apply to these increasingly important orthosilicate refractories. His paper should prove an active, stimulating influence to research directed toward improvement of such materials.

[1] "Refractories and Method of Making." Private communication.

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PETROGRAPHIC AND CERAMIC PROPERTIES OF PENNSYLVANIAN SHALES OF ILLINOIS*

By Ralph E. Grim†

Abstract

Coal Measures shales, which are widespread in Illinois, are used extensively as a ceramic raw material. Ceramic determinations are given for a large number of shales to illustrate the wide range in their properties. The mineral composition, base-exchange capacity, and textural characteristics are presented for the same shales, and the relation of these characteristics to the ceramic properties of the shales is analyzed.

I. Introduction

The bedrock formations immediately underlying about three fourths of the State of Illinois are Pennsylvanian or "Coal Measures" in age and are made up of a large number of beds of sandstone, underclay, coal, limestone, and shale. Many different beds of Pennsylvanian shale as a consequence are to be found outcropping in a large part of the State. These shales are extensively used as ceramic raw material.

The purpose of this research was to investigate the range of ceramic properties of the Pennsylvanian shales; to determine their mineral composition, base-exchange capacity, and texture; and to study some relationships between these factors of composition and ceramic properties. This work is part of the study of the Illinois State Geological Survey of the fundamental factors determining the properties of clays and shales found in Illinois.

II. Procedure

Samples were collected (Table I) from the working pits of many ceramic plants to obtain examples of shales with a wide range of composition and ceramic properties. Where the characteristics of the shale varied in any pit, samples were collected from individual zones in which the characteristics were constant.

Complete mineralogical analyses, based on microscopic, X-ray, and chemical data, were made for each sample. Textural characteristics were obtained by sedimentation analyses and by the study of thin sections with the petrographic microscope. Ceramic tests of each sample were made by the Department of Ceramic Engineering of the University of Illinois.

III. Ceramic Properties

The ceramic properties (Table II) of the Pennsylvanian shales show wide variation. The water of plasticity, for example, varies from 38.5 to 21.0%, the modulus of rupture from 1076 to 162 lb. per sq. in., the volume drying shrinkage from 35.6 to 13.0%, and the volume firing shrinkage from 33.3 to 18.3%. Except for two samples, No. 254 and No. 268, which were gray, the fired color is uniformly red. The shales are not refractory (P.C.E. 3 to 15) and fire at relatively low temperatures (cones 08 to 02).

IV. Texture

To study the relation between mineral composition, texture, and ceramic properties of these shales, the amount of clay minerals, whatever their particle size, and grains of all other minerals smaller than 0.002 mm. were determined microscopically for each shale by running many traverses across several thin sections of each shale. Values for the total amount of clay minerals and grains of other minerals smaller than 0.002 mm., designated for convenience as fraction A, are given in column (2) of Table II.

In Figs. 1 to 6, certain ceramic properties are plotted against the amount of fraction A. These figures show that the total amount of fraction A is an exceedingly important factor in controlling the ceramic properties of these shales. Figures 1, 2, and 3 show that the water of plasticity, modulus of rupture, and drying shrinkage increase with increasing amounts of clay minerals and grains of other minerals smaller than 0.002 mm. in diameter, i.e., fraction A. Shales with values that are higher or lower than the average for one green property usually have higher or lower values, as the case may be, for the other green properties.

The fact that all shales of equivalent fraction A content do not have the same green properties is evidence, if any is needed, that these properties are not controlled solely by the amount of clay mineral and by the amount of material finer than 0.002 mm. Shales with the same amount of fraction A but composed of different kinds of clay mineral will not have the same green properties. Shales, furthermore, with the same amount of fraction A and the same kind of clay mineral but with different textural attributes will not have the same green properties. Plotting of the fraction A content against ceramic properties permits an analysis of the effect of various factors on the ceramic properties of the shales.

Figure 4 shows that firing shrinkage increases with increasing amounts of fraction A. The relation of volume shrinkage to firing temperature for each shale is shown in Fig. 5. Cone values have been translated to degrees centigrade after Fairchild and Peters.[1]

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[1] C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *Jour. Amer. Ceram. Soc.*, 9 [11] 701–43 (1926).

TABLE I
SAMPLES INVESTIGATED

Sample No.	Location	Stratigraphic position
278	Albion Brick Co., Albion Plant No. 2; lowermost 6 ft.	Upper Pennsylvanian shale
280	Hydraulic Press Brick, Edgemont; upper shale	Shale overlying Collinsville limestone
229	Carlinville Tile Co., Carlinville; entire shale	Shale overlying Shoal Creek limestone
241	White Hall Sewerpipe & Stoneware Co., White Hall; uppermost shale	Upper part of Purington shale
254	Sheffield Clay Products Co., Sheffield; lower 8 ft.	Sheffield shale overlying coal No. 6
237	Springfield Clay Products Co., Petersburg; lower 12 ft.	Farmington shale overlying coal No. 7
239	Springfield Clay Products Co., Petersburg; upper 15 ft.	" " " " " "
285	Western Brick Co., Danville; entire shale	" " " " " "
262	Albion Brick Co., Albion Plant No. 1; lower 18 ft.	Upper Pennsylvanian shale
281	Richards Brick Co., Edwardsville; lower 6 ft.	Shale above Trivoli limestone
227	Hydraulic Press Brick Co., Sparland; entire shale	Farmington shale overlying coal No. 7
242	White Hall Sewerpipe & Stoneware Co., White Hall; lower shale	Purington shale overlying coal No. 2
231	Sheffield Clay Products Co., Sheffield; upper 12 ft.	Sheffield shale overlying coal No. 6
213	Hydraulic Press Brick Co., Shale City; entire shale	Gilchrist shale under coal No. 2
243	Poston-Springfield Brick Co., Springfield; upper 15 ft.	Trivoli shale overlying coal No. 8
238	Poston-Springfield Brick Co., Springfield; lower 20 ft.	" " " " " "
240	Purington Paving Brick Co., Galesburg; lower 20 ft.	Purington shale above coal No. 2
275	Alton Brick Co., Alton; lowermost shale	Purington shale overlying coal No. 2
270	Alton Brick Co., Edwardsville; entire shale	Trivoli shale overlying coal No. 8
279	Hydraulic Press Brick Co., Edgemont; lower shale	Shale underlying Collinsville limestone
268	Murphysboro Paving Brick Co., Murphysboro; lower shale	Shale 50 to 60 feet above Murphysboro coal
264	Albion Brick Co., Albion Plant No. 1; upper 20 ft.	Upper Pennsylvanian shale
269	Ford Brick and Tile Co., Harrisburg; entire shale	Shale above coal No. 6

The curves show that shales, e.g., Nos. 241, 278, and 280, which have large amounts of fraction A, tend to have a rapid sharp shrinkage at comparatively low temperatures. As the amount of fraction A decreases, shrinkage becomes more gradual. Shales with small amounts of fraction A attain maximum shrinkage at higher temperatures, and their shrinkage curves are less uniform than those with large amounts of fraction A. The curves were not plotted beyond the temperature of maximum shrinkage because complete data were not available. The limited data, however, indicate that shales rich in fraction A exhibit a longer interval between the temperature at which shrinkage is complete and that at which bloating becomes pronounced than do those with a small amount of fraction A.

Column (11) of Table II shows that zero porosity is reached at successively higher cones in shales with decreasing amounts of fraction A. Shales with large quantities of fraction A show (Fig. 6) a sharp, rapid

TABLE II
CERAMIC DETERMINATIONS

Column (1) sample No.*; (2) fraction A (%); (3) water of plasticity (%); (4) modulus of rupture (lb./sq. in.); (5) modulus of rupture with 50% sand (lb./sq. in.); (6) linear drying shrinkage (%); (7) volume drying shinkage (%); (8) linear firing shrinkage (%)†; (9) volume firing shrinkage (%)†; (10) total linear shrinkage (%); (11) cone of zero porosity; (12) cone of steel hardness; (13) fusion point (P.C.E.); (14) color of fired product.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
278	100	31.0	583	215	8.8	28.8	12.0	31.8	20.8	1	08	10	Red
280	95	30.8	483	227	7.1	22.9	12.0	31.8	19.1	"	"	7	"
229	"	31.8	477	284	7.6	24.5	11.9	31.7	19.5	"	"	14	"
241	"	38.5	1076	351	10.7	35.6	12.4	32.7	23.1	"	"	12	"
254	"	35.6	672	233	8.6	28.1	9.8	26.6	18.4	2	2	3	Dark gray
237	"	29.5	291	169	6.3	20.0	12.6	33.3	18.9	1	08	8	Red
239	90	28.8	302	183	5.9	18.8	12.4	32.7	18.3	"	"	10	"
285	85	26.3	439	220	5.8	18.5	11.0	29.6	16.8	"	"	7	"
262	80	28.2	465	223	6.8	22.0	11.5	30.8	18.3	2	"	14	"
281	"	28.4	424	225	7.1	22.7	11.6	30.9	18.7	3	"	7	"
227	75	26.4	236	100	4.5	14.2	11.9	31.6	16.4	"	02	8	"
242	70	27.1	290	147	6.2	19.8	10.9	29.3	17.1	"	08	11	"
231	65	24.3	302	221	5.5	17.3	11.8	32.3	17.3	"	"	15	"
213	"	28.5	269	152	5.5	17.6	11.4	30.4	16.9	"	02	9	"
243	60	28.0	398	220	5.8	18.4	11.3	30.2	17.1	"	06	13	"
238	"	26.6	260	181	5.0	15.8	10.9	29.3	15.9	"	03	9	"
240	"	26.2	216	156	4.6	14.5	11.9	31.6	16.5	"	"	10	"
275	50	23.5	188	92	4.4	13.9	10.2	27.6	14.6	6	02	11	"
270	"	24.0	214	133	4.8	15.0	9.7	26.5	14.5	5	03	9	"
279	45	23.0	424	219	5.5	17.4	6.5	18.3	12.0	"	08	10	"
268	40	21.3	218	170	4.7	14.9	7.7	21.3	12.4	7	2	14	Dark gray
264	"	23.2	295	178	4.8	15.1	8.9	24.3	13.7	"	03	12	Red
269	30	21.0	162	116	4.2	13.1	8.9	24.5	13.1	5	08	11	"

* Location of sample given in Table I.
† Maximum shrinkage.

loss of porosity at lower temperatures. As the content of fraction A decreases, porosity is lost more gradually and the minimum is reached at a higher temperature.

The data in column (12), Table II, show no definite relationship between the amount of fraction A and the cone at which steel hardness is reached. Shales low in fraction A have the greatest temperature interval between cones of steel hardness and zero porosity and therefore would probably have the greatest firing range.

There is no correlation between fusion point and amount of fraction A. This is expected because the fusion point is closely related to the chemical composition of the clay minerals and may be influenced by small amounts of minor constituents.

Additional textural characteristics of the shales are given in Table III. Silicification (column (3)) refers to the presence of cryptocrystalline silica occurring around the edge of quartz grains and disseminated through the clay-mineral flakes which make up the shale. In the latter case the matrix, as seen by thin-section study, has a dense appearance so that it cannot be resolved into its component parts. Shales showing appreciable silicification (Nos. 237, 239, 227, 240, 275) in general have lower modulus of rupture and drying shrinkage than those without silicification but containing equal amounts of fraction A. The extremely fine silica acts as a cement binding together the particles composing fraction A, thereby having the effect of decreasing the proportion of fraction A. Particles small enough to be classed as fraction A are bound

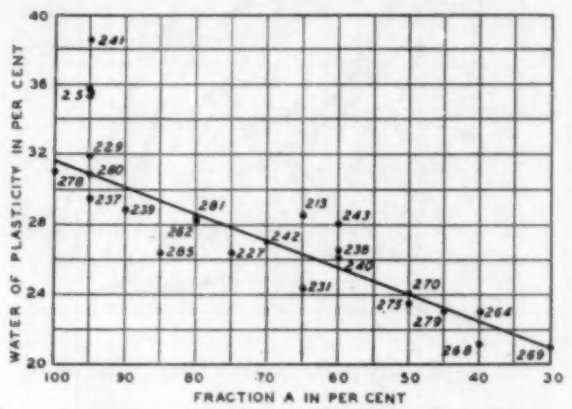

FIG. 1.—Water of plasticity plotted against amount of fraction A.

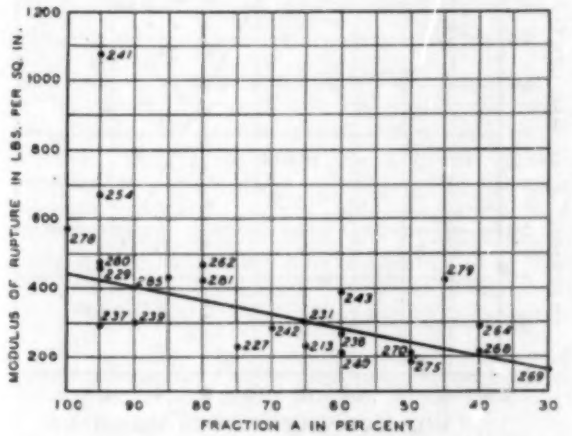

FIG. 2.—Modulus of rupture plotted against amount of fraction A.

TABLE III

TEXTURAL CHARACTERISTICS

Column (1) sample No.; (2) fraction A (%); (3) silicification*; (4) maximum size of clay minerals (mm.); (5) sorting of clay minerals†; (6) degree of uniformity of orientation of clay minerals (%); (7) maximum size of quartz grains (mm.); (8) sorting of quartz grains†; (9) quartz grains scattered (s) or in lenses (l).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
278	100	L	0.005	C	100			
280	95	"	"	A	"	0.03	C	s
229	"	"	0.04	"	75	"	"	"
241	"	"	0.005	"	100	"	"	"
254	"	"	0.02	C	"	"	"	"
237	"	M	0.04	"	75	"	"	"
239	90	"	0.01	A	"	"	"	"
285	85	L	"	"	50	0.04	"	s + l
262	80	"	0.20	"	75	"	"	s
281	"	"	0.01	"	"	0.12	A	"
227	75	M	0.04	C	50	0.06	C	"
242	70	L	0.01	"	75	0.10	"	l + s
231	65	"	0.06	A	50	0.05	"	s
213	"	"	0.01	B	75	0.03	"	"
243	60	"	0.04	C	"	0.06	"	s + l
238	"	M	"	"	25	"	"	" " "
240	"	"	0.03	B	"	0.12	"	s
275	50	"	0.01	C	50	"	"	s + l
270	"	L	"	"	75	0.10	"	l
279	45	"	0.005	B	25	0.06	"	s
268	40	"	0.01	C	50	0.10	"	l + s
264	"	"	"	"	25	0.20	"	" " "
269	30	"	"	"	50	0.06	"	s

* M = large amount of silicification; L = small amount of silicification.

† A = mainly near maximum size; B = mainly too small for size determination; C = unsorted.

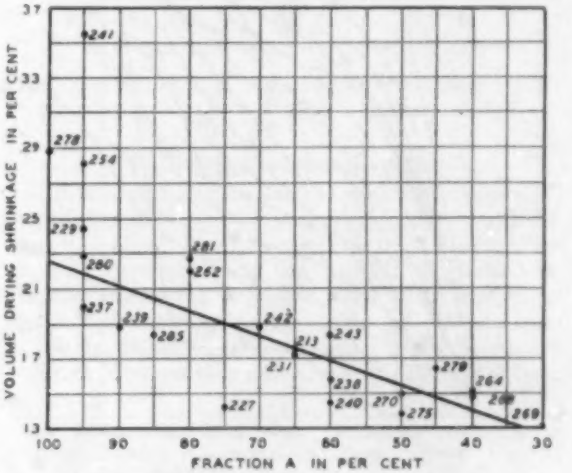

FIG. 3.—Volume drying shrinkage plotted against amount of fraction A.

together into units large enough to act as components larger than fraction A, and, as a consequence, shrinkage and modulus of rupture are reduced.

Shales showing silicification could not readily be disaggregated and placed in suspension, and determinations of the amount of fraction A by sedimentation methods gave lower values than those determined by the study of thin sections.

There is no relation between the maximum size or uniformity of size of the clay-mineral particles (columns (4) and (5), Table III) in the raw shales and their ceramic properties. A consideration of silicification and a microscopic study of thin sections of shales in their natural state and after working with water (e.g., in a pug mill) but before firing provides a satisfactory reason for the absence of such a correlation. Shale No. 254, for example, is composed almost entirely of an unsorted assemblage of clay-mineral flakes with a maximum diameter of 0.02 mm. A thin-section study of the same shale after working but before firing shows it to be composed of clay-mineral flakes usually less than 0.002 mm. and with a maximum diameter of 0.007 mm. Working, therefore, has reduced the size of the clay-mineral flakes so that the size of particles in the raw shale and in the worked shale is not the same. Two shales containing clay-mineral particles of the same diameter, furthermore, would not exhibit the same ceramic properties if one were silicified because they

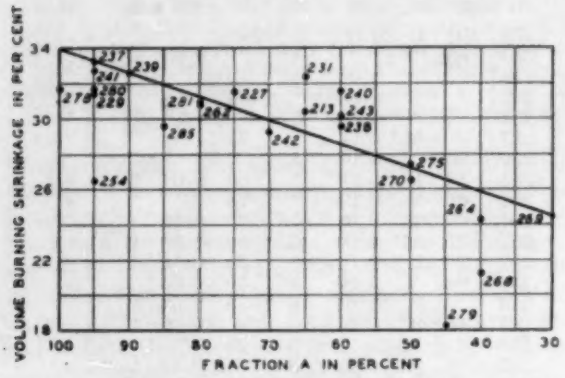

FIG. 4.—Volume firing shrinkage plotted against amount of fraction A.

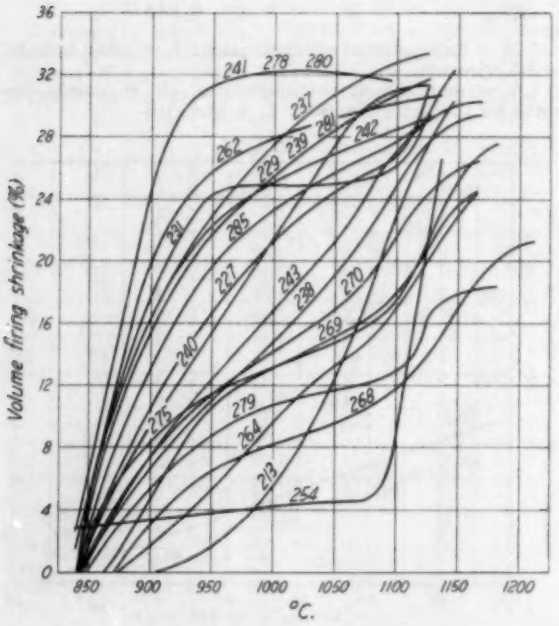

FIG. 5.—Volume firing shrinkage plotted against firing temperature.

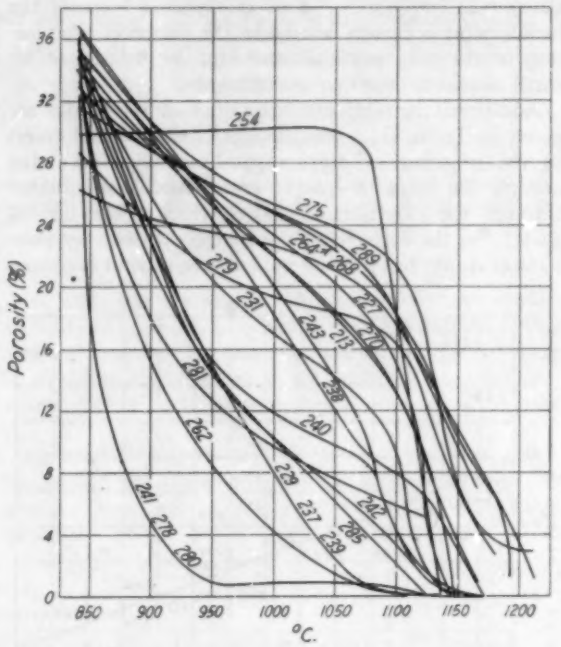

FIG. 6.—Porosity plotted against firing temperature.

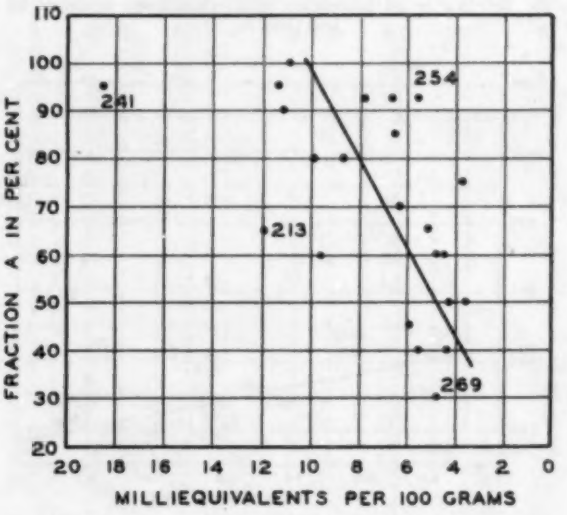

FIG. 7.—Base-exchange capacity plotted against amount of fraction A.

would not break down to the same degree when worked in water. It is clear that any correlation of ceramic properties and particle size must be made on the basis of "effective particle size," that is, the size of the material after working. Effective particle size is not always the same as the particle-size make-up of the raw shale.

Degree of uniformity of orientation of clay minerals (column (6), Table III) refers to the uniformity of crystallographic orientation of the clay minerals in the shale. An analysis of this and other textural attributes listed in Table III and not previously discussed shows no correlation with the ceramic properties listed in Table II. Other properties may be related to these textural attributes. The tendency of a shale, for example, to develop lamination planes during extrusion is probably controlled, at least in part, by the perfection of crystal form and degree of aggregate orientation of the clay-mineral flakes.

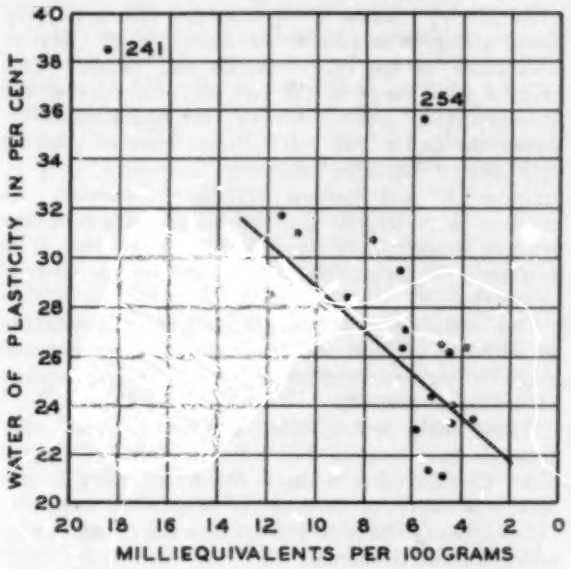

FIG. 8.—Water of plasticity plotted against base-exchange capacity.

V. Mineral Composition

The mineral composition of the −0.002-mm. fraction of each shale was determined by X-ray and optical methods. Except for sample No. 241, the −0.002-mm. fraction of all shales is composed of the clay minerals, illite[2] and kaolinite, with minor amounts of chloritic mica, quartz, limonite, and organic material. Illite is more abundant than kaolinite. Shale No. 241 contains montmorillonite in addition to these constituents, and Table I shows that this shale has much higher water of plasticity, modulus of rupture, and drying shrinkage than any of the other shales. This is in agreement with the conclusion of an earlier paper[3] that the presence of montmorillonite causes a clay to have high water of plasticity, bonding strength, and shrinkage.

Illite is known[4] to vary in its attributes, and before a specific correlation of properties and mineral composition is attempted for these shales, work in progress on the detailed properties of illite must be completed. Variations within the illite group of clay minerals must be known before a close correlation can be worked out.

The portion of the shales other than fraction A is made up essentially of quartz. A very few grains of orthoclase, pyrite, zircon, and tourmaline are also present. In none of the shales studied are the nonclay minerals, other than quartz, present in quantities large enough to affect the unfired properties.

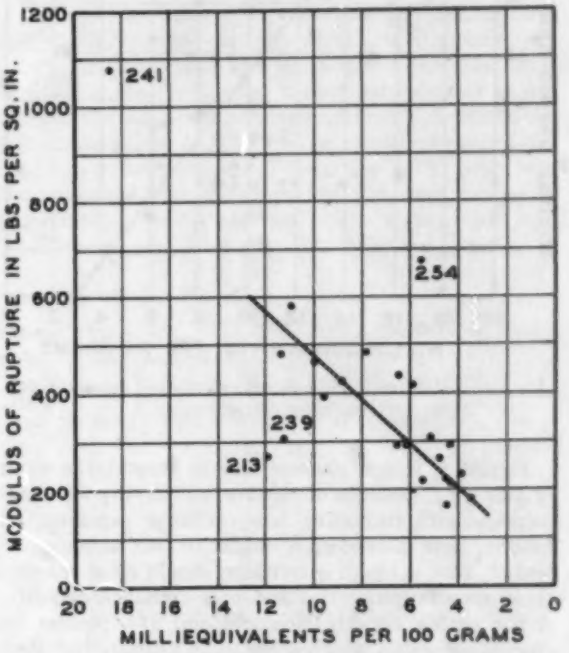

FIG. 9.—Modulus of rupture plotted against base-exchange capacity.

VI. Base-Exchange Capacity

The base-exchange capacity of each shale (Table IV) was determined by the ammonium-acetate method. Figure 7 shows that, in general, the base-exchange capacity increases with the amount of fraction A. Because fraction A is approximately the component of the shale carrying the base-exchange capacity, that is, the clay minerals, this relationship is to be expected. Fraction A, however, also contains quartz and is a

[2] In an earlier paper, R. E. Grim, "Petrology of Pennsylvanian Shales and Noncalcareous Underclays Associated with Illinois Coals, Including X-Ray Studies by P. F. Kerr and Chemical Studies by O. W. Rees, I–III," *Bull. Amer. Ceram. Soc.*, 14 [3] 113–19; [4] 129–34; [5] 170–76 (1935), this component was designated as the sericite-like mineral.

[3] R. E. Grim and R. H. Bray, "Mineral Constitution of Various Ceramic Clays," *Jour. Amer. Ceram. Soc.*, 19 [11] 307–15 (1936).

[4] R. E. Grim, "Relation of Composition to Properties of Clays," *ibid.*, 22 [5] 141–51 (1939).

mixture of clay minerals with different exchange capacities so that a *close* relationship should not exist.

Montmorillonite possesses a higher base-exchange capacity than either illite or kaolinite. Shale No. 241, which contains montmorillonite, has a much higher exchange capacity than any other of the shales.

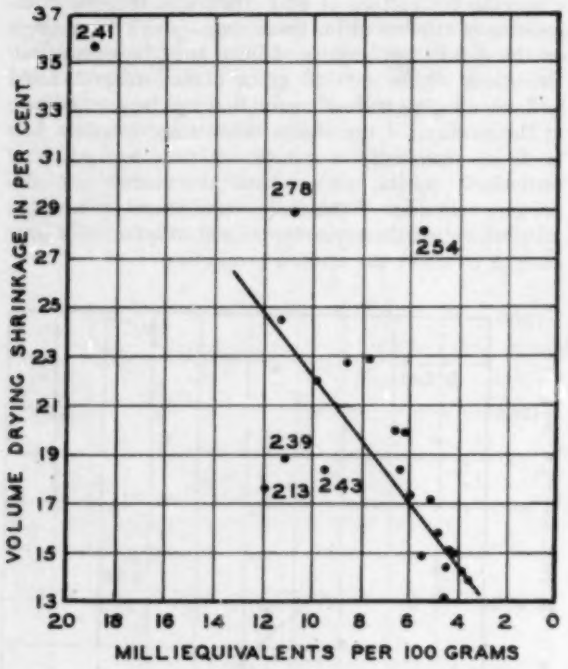

FIG. 10.—Volume drying shrinkage plotted against base-exchange capacity.

Figures 8, 9, and 10 show that, in general, the water of plasticity, modulus of rupture, and drying shrinkage increase with increasing base-exchange capacity. It follows, from a discussion similar to that already presented, that a rough correlation should exist between these ceramic properties and base-exchange capacity. A few shales, notably Nos. 254 and 213, possess exchange capacities which seem to be unrelated to their unfired properties. The reason for this absence of correlation is not yet known.

VII. Conclusions

All of the shales of Pennsylvanian age in Illinois are composed principally of clay minerals (illite and minor amounts of kaolinite) and quartz. Chloritic mica, limonite, organic material, feldspar, and heavy minerals are minor and relatively unimportant components.

TABLE IV

BASE-EXCHANGE CAPACITIES*

Sample No.	Exchange capacity (m.e./100 gm.)	Sample No.	Exchange capacity (m.e./100 gm.)
278	10.9	231	5.1
280	7.7	213	11.9
229	11.3	243	9.5
241	18.5	238	4.8
254	5.5	240	4.4
237	6.5	275	3.5
239	11.1	270	4.2
285	6.4	279	5.9
262	9.9	268	5.4
281	8.7	264	4.3
227	3.7	269	4.6
242	6.2		

* Determinations made under the supervision of O. W Rees, chemist, Illinois State Geological Survey.

As far as mineral composition is concerned, the shales differ from each other chiefly in the relative abundance of the clay minerals and quartz. This gives a wide range in the ceramic properties of the Pennsylvanian shales. A close correlation exists between the amount of −0.002-mm. material plus all clay-mineral particles whatever their size, that is, fraction A and certain ceramic properties. As fraction A is largely the clay-mineral fraction, the relative abundance of clay minerals in the shale is an extremely important factor in determining ceramic properties.

One of the samples which contained montmorillonite in addition to illite and kaolinite as a consequence exhibited higher values for unfired properties than any other sample studied.

Those shales which show silicification of the clay minerals have reduced values for their unfired properties. Certain other textural attributes, such as size and uniformity of orientation of clay-mineral particles, appear to have no influence on the ceramic properties considered herein.

Base-exchange capacity, which is a characteristic of the clay minerals, has a direct bearing on the unfired properties. The correlation, however, between base-exchange capacity and unfired properties cannot be close unless all materials have exactly the same clay-mineral composition and the same exchangeable base is present in each material.

ILLINOIS STATE GEOLOGICAL SURVEY
URBANA, ILLINOIS

EFFECT OF TIME AND TEMPERATURE ON ACCELERATED CHEMICAL DURABILITY TESTS MADE ON COMMERCIAL GLASS BOTTLES, II*

By Frank R. Bacon and O. G. Burch

Abstract

The effects of storage of solutions in glass bottles at room temperature are compared with the results of various accelerated tests with corresponding solutions in the first paper of this series. The acid tests at room temperature are in good agreement with those at higher temperatures.

Relative resistances of glass bottles as shown by accelerated tests with water *roughly* parallel relative resistances appearing in room-temperature storage of unbuffered, neutral materials *only* if the various amounts of extraction are approximately the same at both temperatures.

The tendency of bottles to produce flakes or insoluble matter in alkaline solutions bears no direct relation to the amount of soluble matter extracted by such solutions.

I. Introduction

A general discussion of accelerated chemical durability test methods with references to the most pertinent literature was included in the first paper of this series.[1] Results of thirty-nine tests with eleven different compositions of 4-ounce "Boston round" bottles (except bottles E, which are oval) were presented. These included (1) crushed-sample tests with (*a*) dilute acid and (*b*) distilled water, and (2) tests on the inside surfaces of the bottles with (*a*) dilute acid, (*b*) water, and (*c*) $N/50$ sodium hydroxide. The crushed-sample tests were made by The American Ceramic Society tentative method No. 1, involving the leaching of sieved grains with dilute acid, and a modification in which distilled water was substituted for the acid. The bottle tests were run for a variety of periods at five temperatures between 50° and 130°C. The so-called "titratable alkali" was measured under all conditions, and in a few cases the total extracted material was determined by weighing the ignited "total solids as sulfates."

The present paper consists largely in an extension of the experiments to room temperature for periods up to fourteen months. The observations include both volumetric and gravimetric estimation of material extracted, a detailed study of flaking behavior with water, and the analysis of the insoluble matter formed during the storage of sodium hydroxide.

II. Experimental Results

The methods of determining material extracted are described in the first paper and will not be detailed here except where modifications have been employed. Room temperature as used throughout refers to the laboratory temperature and was subject to seasonal variation between 23° and 32°C.; as the various tests were initiated at approximately the same time however, the results are comparable.

(1) Dilute Acid Tests

The data in Table I were obtained by maintaining bottles filled to rated capacity with $N/1000$ sulfuric acid for the indicated time and temperature and then back titrating in the presence of methyl red indicator to determine the alkaline material extracted. $N/1000$ acid was suggested by Lyle.[2] Its use greatly increases the precision of the method. The tests at 95°C. were run for comparison with tests reported in the first paper,[3] in which 0.0085 N acid was used. The tests at 50° and 121°C. are an addition to the data of the first paper.

Table I

Alkali Extraction by $N/1000$ H_2SO_4 (NaOH mg./liter)

	Room temp. (°C.)		50°C.		95°C.	121°C.		
Bottle No.	6 mo.	1 yr.	10 wk.	20 wk.	24 hr.	1 hr.	3 hr.	5 hr.
A	6	7	12	16	14	10	15	19
	6	6	11	17	15	11	15	19
B	1.5	1.5	3	4	3	3	4	6
	1	1.5	3	4	3	3	5	6
C	5	7	11	18	11	8	13	16
	5	6	11	15	12	9	13	16
D	3	4	7	9	7	6	9	11
	3	4	7	9	8	6	9	11
E	3	4	7	8	8	6	9	11
	3	4	7	9	8	7	9	12
F	7	8	13	21	15	12	17	22
	6	8	13	18	15	12	17	22
G				7				
				9				
H	6	8	13	16	15	11	16	20
	7	8	13	19	14	11	16	20
I	13	15	24	30	25	20	27	34
	13	15	24	29	25	20	27	34
J	8	10	15	21	13	13	17	22
	7	9	15	23	14	13	17	22
K	3	4	6	7	6	5	7	10
	3	4	5		6	5	8	10

The tests run at 121°C. were conducted in an autoclave, using thirty minutes to heat up and also to cool down. The bottles were filled brimful and loosely closed by crimping tin-foil over the mouths. During the heating-up period, the excess of liquid resulting from

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Approved manuscript received June 8, 1940.

[1] F. R. Bacon and O. G. Burch, "Effect of Time and Temperature on Accelerated Chemical Durability Tests Made on Commercial Glass Bottles," *Jour. Amer. Ceram. Soc.*, **23** [1] 1–9 (1940); correction, *ibid.*, [2] 56 (1940).

[2] A. K. Lyle, private communication, March 4, 1939.

[3] F. R. Bacon and O. G. Burch, *loc. cit.*, Table III, p. 3.

thermal expansion escaped and the bottles were brimful during the period at 121°C. A variable amount of mechanical loss occurred during the cooling-down period owing to flashing. Concentration of solutions by evaporation, however, was negligible. The back titration therefore could be accurately performed on any definite amount of solution pipetted out of a bottle after cooling to room temperature.

Table II shows results obtained gravimetrically after storage of both concentrations of acid at room temperature.

TABLE II

MATERIAL EXTRACTED BY ACID AT ROOM TEMPERATURE

	Total solids as sulfates (mg./l.)		
Concentration:	0.0085 *N*	0.0085 *N*	0.001 *N*
Time:	6 mo.	1 yr.	1 yr.
Bottle No.			
A	14	19	15
		20	17
B	3	8	4
		4	6
C	10	19	13
		16	21
D	8	13	15
		11	14
E	8	13	15
		11	11
F	14	20	13
		15	16
G	7	13	
		10	
H	14	21	24
		17	17
I	21	32	34
		27	30
J	19	24	29
		21	23
K	7	11	6
		8	9

(2) Distilled Water Tests

Table III shows results obtained by storage of CO_2-free, distilled water at room temperature. "Alkali as NaOH" and "total solids as sulfates" were determined successively on each solution.

Twenty sets of bottles were filled with water and stored in corrugated cartons at room temperature for this study. For the first six months of storage, the bottles in one of these cartons were examined at intervals of two months. At the end of six months, no bottle in the carton showed the presence of visible flakes. The titratable alkaline matter and total extracted materials were determined at that time on all bottles in this carton. After eight months, some flakes were present in all of the 19 sets remaining, but there was considerable variation in the condition of certain kinds of bottles from set to set. One of the sets showing the least amount of flaking and one showing the most were chosen for the determinations reported for eight months in Table III. After ten and twelve months, the 17 remaining sets were examined. The determinations reported for one year were made on one set showing about the least flaking and one set which showed among the most. Flaking observations were made after fourteen months on the remaining sets.

Table IV shows the results of the flaking observations. For every period, the percentage of each kind of bottle falling in each of five classes is reported. The subjective nature of such observations prevents the simple classification of flakes present and absent. Of the classes chosen, "none" and "very small or questionable" are self-explanatory. "Moderate" and "considerable" refer to amounts of flaking definitely apparent in normal room light. The latter refers to amounts which might be noticed by any casual observer, such as the purchaser of a bottled liquid. The observations were made by illuminating the bottles from their bottoms in a dark room. This was supplemented by observation in a normally illuminated room and in daylight.

TABLE III

EXTRACTION BY WATER AT ROOM TEMPERATURE*

	6 months		8 months		1 year	
Bottle No.	Alkali as NaOH- (mg./ l.)	Total solids as sulfates (mg./l.)	Alkali as NaOH- (mg./ l.)	Total solids as sulfates (mg./l.)	Alkali as NaOH- (mg./ l.)	Total solids as sulfates (mg./l.)
A	10	25	10	30	10	40
			12	37	12	36
B	6	18	5	16	6F	28F
			7	25	9	27
C	10	30	11	32	13F	47F
			12F	35F	14F	46F
D	7	19	7	20	9F	34F
			8F	29F	10F	33F
E	7	19	5	12	9	37
			8	28	10	28
F	14	38	15	42	15F	53F
			16	47	16	52
G	10	33	11	36	10F	43F
			12F	40F	12	46
H	13	43	11F	32F	16F	56F
			12F	35F	19F	64F
I	17	48	20F	53F	21F	70F
			20F	58F	22F	64F
J	12	36	13F	36F	15F	53F
			16F	53F	16F	49F
K	14	45	15F	45F	16F	64F
			17F	56F	19F	60F

* The symbol, "F," following any numerical value in this table indicates presence of flakes or spicules in the solution.

(3) Sodium Hydroxide Tests

The results obtained by storage of *N*/50 sodium hydroxide at room temperature are presented in Table V. The procedure of determinations follows:

At the end of the storage period the contents of a bottle is filtered through retentive paper into a dry beaker. Forty cubic centimeters of each filtrate is pipetted out and titrated with standard sulfuric acid, using methyl red indicator. An excess of sulfuric acid is then added, and the solids as sulfates are determined in the usual manner. The bottle and the insoluble residue on the filter are washed ten times with 1:40 ammonia water. The washed residue is ignited in the presence of sulfuric acid and weighed. "Alkali as NaOH" is calculated from the difference between the titer and the blank. "Net total solids as sulfates" equals the weight of solids as sulfates plus "insoluble solids as sulfates" (both directly determined) minus the

TABLE IV

VISIBLE FLAKING DURING STORAGE OF WATER AT ROOM TEMPERATURE

Bottle No.	Time	Percentage of each kind of bottle showing various amounts of flaking: None	Very small or questionable	Moderate	Considerable
A	8 mo.	100	0	0	0
B	"	100	0	0	0
C	"	16	37	47	0
D	"	5	58	37	0
E	"	100	0	0	0
F	"	95	0	5	0
G	"	42	42	16	0
H	"	0	32	68	0
I	"	0	0	64	16
J	"	0	0	26	74
K	"	0	26	74	0
A	10 mo.	88	12	0	0
B	"	41	41	18	0
C	"	0	18	82	0
D	"	0	12	82	0
E	"	94	6	0	0
F	"	41	35	24	0
G	"	18	12	70	0
H	"	0	6	94	0
I	"	0	0	82	18
J	"	0	0	6	94
K	"	0	6	94	0
A	1 yr.	76	24	0	0
B	"	0	35	65	0
C	"	0	12	88	0
D	"	0	6	94	0
E	"	88	12	0	0
F	"	41	35	24	0
G	"	0	12	88	0
H	"	0	0	100	0
I	"	0	0	82	18
J	"	0	0	0	100
K	"	0	0	100	0
A	14 mo.	72	14	14	0
B	"	0	29	71	0
C	"	0	0	86	14
D	"	0	7	93	0
E	"	64	29	7	0
F	"	42	29	29	0
G	"	0	14	72	14
H	"	0	0	43	57
I	"	0	0	29	71
J	"	0	0	0	100
K	"	0	0	36	64

weight of Na_2SO_4 equivalent to the NaOH originally introduced. The results are reported in milligrams per liter.

The insoluble matter developed in 6 of the bottles after about eight months' storage at room temperature was analyzed by the following procedure[4]:

The insoluble matter, removed and washed as described in this section is ignited in platinum (without addition of sulfuric acid) and weighed. Silica is then removed by treatment with hydrofluoric and sulfuric acids. The baked residue is leached with dilute hydrochloric acid, and the insoluble $BaSO_4$ is filtered out, washed, and ignited. The R_2O_3 is determined in the filtrate by precipitation with ammonium chloride and ammonium hydroxide, followed by washing and ignition to oxides. Calcium is precipitated as the oxalate and determined by titration with dilute permanganate solution. Magnesium is precipitated in the filtrate and filtered, washed, dried, and weighed as the quinolate in sintered glass crucibles. The filtrate is freed of organic matter and ammonium salts by treatment with nitric acid and evaporation to dryness. Sodium is determined in the residue by the triple-acetate method. The difference between the weight of the determined oxides and the ignited insoluble matter is taken to be SiO_2.

The amounts of ignited material available for analysis ranged from 15 to 24 mg. The procedure described was accordingly carried through with small volumes. The reader may judge what errors fall in the silica value. Table VI shows the results obtained.

III. Discussion of Results

(1) Dilute Acid Tests

The average of determinations reported in Tables I and II and in the first paper,[5] for each bottle under each set of conditions in acidic media, are shown in Table VII. The bottles are in the order of average resist-

[4] The separations and determinations referred to are discussed in W. F. Hillebrand and G. E. F. Lundell, Applied Inorganic Analysis, John Wiley and Sons, New York, 1929, and in other standard works.

[5] F. R. Bacon and O. G. Burch, *loc. cit.*, Tables II and III, pp. 2 and 3.

TABLE V

EXTRACTION BY *N*/50 NaOH AT ROOM TEMPERATURE

Bottle No.	6 months: Alkali as NaOH (mg./l.)	6 months: Net total solids as sulfates (mg./l.)	6 months: Insoluble solids as sulfates (mg./l.)	10 months: Alkali as NaOH (mg./l.)	10 months: Net total solids as sulfates (mg./l.)	10 months: Insoluble solids as sulfates (mg./l.)
A	20	200	21	66	430	51
B	82	570	200	160	1250	350
C	76	490	120	150	1120	240
D	60	480	110	110	820	150
E	32	290	14	66	460	48
	38	290	26			
F	56	390	100	130	910	240
G	92	610	180	200	1480	370
H	100	680	150	210	1420	300
I	84	580	100	170	1250	220
J	98	640	160	200	1420	310
K	110	650	250	220	1630	480

ance from best to worst. This ranking permits an easy observation of the correlation between tests.

There is only one significant discrepancy in column (1) of Table VII showing the crushed-sample results. Bottle B is only slightly better than G, K, and E by this test, but it is far better by all of the bottle-surface tests.

TABLE VI

COMPOSITION OF IGNITED INSOLUBLE MATTER RESULTING FROM STORAGE OF *N*/50 NaOH FOR EIGHT MONTHS

	Bottle No.					
	C (%)	D (%)	G (%)	H (%)	I (%)	J (%)
SiO_2	53	52	56	53	49	55
R_2O_3	3	5	2	5	7	6
CaO	21	20	22	21	21	20
MgO	16	16	14	17	17	17
BaO	3	4	4	1	1	0.4
Na_2O	3	3	2.5	3	5	2

The only values that are out of the average order of resistance to a significant extent are those for H and J in column (10), C, H, and J in column (11), and J in column (16). Column (11) shows the severest test to which the bottles were subjected. Bottles H and J were perceptibly weathered when received. The assumption that the removal of the weathering products by the washing process prior to test left a surface more resistant to prolonged acid attack would explain all discrepant results except that for bottle C in column (11). This assumption is reasonable, but is certainly not known to be true.

various bottles to 90 (odd) % of all bottled products (those which are acidic), which requires less than two and one-half hours of elapsed time. Tables I and VII show that such a test is significantly more severe than one year of storage at room temperature.

The American Ceramic Society tentative method No. 1 also parallels room-temperature storage. A test of this type is useful in comparing the relative resistances of different glass compositions, particularly when the size or shape of the various lots of bottles under consideration is different or when their storage histories are different or unknown.

Columns (5) and (6) and columns (14) and (15) in Table VII show comparisons of extraction by 0.0085 *N* acid and 0.001 *N* acid under the same conditions. The values shown check within the accuracy of individual determinations and demonstrate the independence of acid extraction and acid concentration.

(2) Distilled Water Tests

It has been shown in the first paper[1] that when water is the leaching medium the relative resistances of a series of bottles under one set of conditions may be different than under conditions of greater or less severity even though the temperature is not changed. The data presented in that paper also show that, for a given kind of bottle and a given temperature, the temperature coefficients for tests of two different lengths are often widely different. It is therefore apparent that the relation between temperature and amount of extraction for a given period of test is highly complex.

TABLE VII

AVERAGES FOR ALL TESTS WITH ACIDS

	90°C.	Room temp. (°C.)					50°C.		75°C.			95°C.					121°C.		
N of acid	.02	.001	.001	.0085	.0085	.001	.001	.001	.0085	.0085	.0085	.0085	.0085	.0085	.001	.0085	.001	.001	.001
Time	4 hr.	6 mo.	1 yr.	6 mo.	1 yr.	1 yr.	10 wk.	20 wk.	7 da.	14 da.	35 da.	4 hr.	12 hr.	24 hr.	24 hr.	24 hr.	1 hr.	3 hr.	5 hr.
Method	Vol.*	Vol.†	Vol.	Grav.‡	Grav.	Grav.	Vol.	Vol.	Vol.	Vol.	Vol.	Vol.	Vol.	Vol.	Vol.	Grav.	Vol.	Vol.	Vol.
Bottle No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
B	0.028	1	1.5	3	6	5	3	4	2	5	11§	2	3	4	3	12	3	5	6
G	.029			7	11			8	5	8	21	4	5	7		21			
K	.031	3	4	7	9	8	5	7	5	10	21	4	5	8	6	25	5	8	10
E	.030	3	4	8	12	13	7	8	7	13	20	4	6	9	8	23	6	9	11
D	.035	3	4	8	12	14	7	9	6	11	21	5	7	9	8	27	6	9	11
C	.053	5	7	10	17	17	11	16	11	24	50	7	10	15	12	36	8	13	16
A	.052	6	7	14	19	16	11	16	15	23	42	9	13	18	15	35	10	15	19
H	.058	6	8	14	19	20	13	17	15	19	29	8	11	16	15	36	11	16	20
F	.062	6	8	14	17	15	13	19	15	25	51	9	13	18	15	41	12	17	22
J	.061	7	9	19	22	26	15	22	18	22	31	9	12	17	14	37	13	17	22
I	.079	13	15	21	29	32	24	29	26	35		14	20	28	25	57	20	27	34

* American Ceramic Society tentative method No. 1 (alkali dissolved as % Na_2O).
† Alkali as NaOH(mg./l.).
‡ Total solids as sulfates, mg./l.
§ The values shown in the first paper (22, 21) appeared improbable; another determination yielded the value shown here.

As Table VII shows good correlation, it may be stated that accelerated bottle tests with dilute acid parallel room-temperature storage of acidic materials, provided the tests are not excessively severe. The fact that the autoclave test technique, using *N*/1000 acid, yielded reproducible values closely paralleling room-temperature results is particularly promising. Using the one-hour period at 121°C., this technique provides a precise method of testing the relative resistance of

What should be a more definite function is the relation between temperature and time required to accomplish a certain amount of extraction with a given bottle. If the relation between temperature and time is similar for all bottles, "a certain severity of conditions" may be substituted for "a certain amount of attack," and a basis is provided for the correlation of accelerated test results with room-temperature storage.

Table VIII shows the average value for each kind of bottle in each of seven tests. The bottles are listed in the order of average resistance shown by the six bottle-surface tests of similar severity. The averages are based on values reported in Table III and also on those in the first paper.[6] The values in columns (4) and (5) were interpolated from enlargements of Figs. 4 and 5 of that paper.[7] The values in column (6) represent a condition of slightly greater severity because the data obtained at 121°C. were insufficient to justify interpolation. The value for bottle A (or C) in column (2) is the only bottle-test result out of the average order to a significant extent, and here the difference is small. No correlation can be observed between the crushed sample test with water (column 1) and the bottle-surface tests.

TABLE VIII

AVERAGES FOR VARIOUS TESTS WITH WATER

	Crushed sample (% Na_2O)	Bottle surface tests Alkali extracted as NaOH (mg./l.)*				
	90°	R.T.	50°C.	75°C.	95°C.	121°C.
Time	4 hr.	1 yr.	3 wk.	2 da.	7 hr.	1 hr.
Bottle No.	(1)	(2)	(3)	(4)†	(5)†	(6)
B	0.037	7F	7	6	7	7
D	.035	9F	9	9	9	10
E	.027	9	9	11	10	13
G	.042	11F	11	11	11F	14F
C	.050	13F	13	12	14	14F
A	.040	11	14	16	16	18
J	.060	15F	15	16F	15F	19F
H	.061	17F	16	17F	15	19F
K	.051	17F	18F	20F	15F	23F
F	.056	16F	17	21	19	23F
I	.069	21F	22F	24F	21F	26F

* Symbol "F" following any numerical value indicates presence of flakes or spicules in solution.

† Values interpolated from Figs. 4 and 5 of the first paper.

Table IX shows a similar tabulation of values for three bottle-surface tests with water of fairly uniform severity which were chosen from those reported in the first paper.[6] The amounts of extract are several times the amounts shown in Table VIII. Considerable differences occur between the three values for bottles G and K. Inspection of Figs. 4 and 5 of the first paper[7] indicates that at the conclusion of tests of the severity shown, G and K have both reached a stage of accelerated attack where slight differences of time (or temperature) result in large differences in amounts of extraction. Except for bottle G, the only inversion in order of resistance occurring in this table is between bottles F and I in column (2). Although the order of resistance here is entirely different from that shown in Table VIII, the crushed-sample test results cannot be correlated with these data either.

Tables VIII and IX demonstrate that fair correlation may be obtained in bottle-surface tests with water under various conditions of equivalent severity as far as alkali extracted is concerned. In choosing, therefore, an accelerated test with distilled water to parallel room-temperature storage of a neutral, unbuffered, liquid product, the severity of test should be equivalent to the longest reasonable period of storage at room temperature that this product ever experiences. Any test of greater severity will be unfair to the glass manufacturer and misleading to the bottle purchaser. Lyle[8] has already stated this principle.

It should not be overlooked, however, that this investigation has been limited to tests on 4-ounce bottles. If, for example, some lots of 8-ounce bottles corresponding in shape, composition, and storage history to the various lots of 4-ounce bottles had been available, a group of such 8-ounce bottles would be expected to rank in a very different order of resistance than the present bottles under given test conditions (time and temperature). The ratio of capacity (or volume) to surface area is increased 59% when the capacity is doubled. As a result, the concentration of alkaline material would always be less during the progress of the test. The test therefore would be much less severe for the larger bottles.

TABLE IX

AVERAGES FOR THREE BOTTLE-SURFACE TESTS WITH WATER

	Alkali extracted as NaOH (mg./l.)		
	75°C.	95°C.	121°C.
	7 days	24 hr.	3 hr.
Bottle No.	(1)	(2)	(3)
B	17	15	18F
D	19	19F	22F
E	20	22	24
C	24F	26F	27F
A	29	31	33
F	39	43	42F
G	53F	28F	42F
I	46F	38F	43F
J	53F	47F	46F
H	59F	50F	49F
K	110F	81F	81F

The authors have shown elsewhere[9] that corrosion of glass bottles by neutral 40% by volume alcoholic solutions proceeds only one fifth to one tenth as fast as with water. This fact should not be omitted from consideration in the selection of a distilled-water test to be used as a quality criterion of bottles purchased for the storage of essentially neutral, unbuffered products of such alcoholic content, e.g., gin.

All of the results in Tables III, VIII, and IX, and in a tabulation of water tests in the first paper[6] show erratic behavior in the formation of flakes with distilled water as well as the absence of correlation between material extracted and flake formation. Table IV, showing the results of observations for flaking made periodically on 15 to 20 bottles of each type, demonstrates that flaking must be considered as a probability rather than as some-

[6] *Ibid.*, Table IV, p. 3.

[7] *Loc. cit.*, p. 6.

[8] A. K. Lyle, "Relation Between Storage and Accelerated Chemical Durability Tests for Several Glass Compositions." Paper presented at the Autumn Meeting of the Glass Division, Skytop, Pa., September 9, 1939.

[9] F. R. Bacon and O. G. Burch, "Resistance of Glass Bottles to Neutral Alcoholic Solutions," *Jour. Amer. Ceram. Soc.*, **23** [5] 147–51 (1939).

thing that appears at a definite point during the progress of attack. If, as is supposed, flakes form by a sloughing off of very thin films from the bottle walls, it may well be that the time at which such film fragments detach themselves is affected by rather obscure circumstances.

Table X shows the order of resistance of the bottles to flaking as indicated (*a*) by duplicate tests at 121°C., (*b*) by consideration of the results of all accelerated tests with water,[6] and (*c*) by the observation, after four periods, of a large number of the bottles stored simultaneously at room temperature. Fair correlation appears between the order of resistance indicated by all accelerated tests and the order of resistance observed at room temperature. There are no adequate data showing whether flakes appear at higher or lower extraction values at elevated temperature than at room temperature as observation of a sufficient number of bottles has been carried out only at room temperature. Preliminary indications are that they form at room temperature at values at least as low as at any higher temperature.

TABLE X

ORDER OF RESISTANCE TO FLAKING WITH WATER (FROM MOST TO LEAST)

121°C. 1 hr.	All accelerated tests	Room temp. storage (months)			
		8 mo.	10 mo.	12 mo.	14 mo.
	A	ABE	AE	E	E
ABDE	E			A	A
	BF		B	F	F
		F	F	B	B
	D	G	G	GC	D
	C	C	CD		G
	G	D		D	C
CFGHIJK	H	H	HK	HK	H
	K	K			K
	I	I	I	I	I
	J	J	J	J	J

The important influence of weathering on flaking is not considered in this study. It should not be overlooked, however, that a glass composition may have splendid resistance to flaking, and yet bottles of this composition may readily produce flakes if they are filled with an aqueous solution after unfavorable storage conditions have produced weathering on the inside surfaces.

(3) Sodium Hydroxide Tests

The most important consideration in the storage of alkaline solutions is the amount of unsightly insoluble matter which develops in the bottle. This was determined for periods of six and ten months of storage at room temperature and is shown in Table V. Bottles A and E yielded far the least insoluble matter for both periods. The superiority of these bottles was easily detectable by visual observation at the end of two months.

Table XI shows a comparison of the insoluble matter developed in ten months at room temperature with alkali extracted from the bottles under the same conditions and with the alkali extracted[10] from similar bottles in twenty-four hours at 95°C. The bottles in this table are arranged in the order of their resistance to the formation of insoluble matter. The failure of the amount of extracted alkali to index the amount of insoluble matter developed under the same conditions is demonstrated by the values for bottles I, H, and B in column (2) of this table. The more complete failure of the accelerated test is shown by the random order of the values in column (3).

TABLE XI

AVERAGES FOR THREE TESTS WITH *N*/50 NaOH

	10 months room temp.		24 hr., 95°C.
Bottle No.	Insoluble matter as sulfates (mg./l.) (1)	Alkali extracted as NaOH (mg./l.) (2)	Alkali extracted as NaOH (mg./l.) (3)
E	48	66	135
A	51	66	75
D	150	110	140
I	220	170	185
F	240	130	130
C	240	150	155
H	300	210	195
J	310	200	200
B	350	160	135
G	370	200	175
K	480	220	145

It appears that the best way to test bottles for service with products whose alkalinity is comparable to that of *N*/50 sodium hydroxide is to fill them with the product in question and to observe them at intervals for the relative quantity of insoluble matter apparent to the eye. This is further desirable because the nature and concentration of alkaline solution undoubtedly will affect the results.

Table VI shows the analyses of the insoluble matter developed in several of the bottles in about eight months. The sodium oxide reported, rather than a fundamental constituent of the flaky, insoluble matter, may have been adsorbed or occluded. The ten washings which preceded analysis should have removed any readily liberated material. It may be noted that R_2O_3 and all dibasic oxides are present in greater percentage than in the original glasses, that silica is present in decidedly less percentage, and the sodium oxide content is very low.

IV. Conclusions

The general conclusions to be drawn from both the first and the present paper of this series are as follows:

(1) The resistances of glass to acidic solutions, to neutral and unbuffered solutions, and to initially alkaline solutions are independent of one another and must be tested separately.

(2) The American Ceramic Society tentative method No. 1 (crushed-sample test with acid) gives results which may be interpreted in terms of the relative resistances of unweathered bottles of like sizes and shapes to acidic products at room temperature.

[10] Averages of values reported in the first paper, *loc. cit.*, Table V, p. 4.

(3) Accelerated bottle-surface tests with dilute acid may be interpreted in terms of the relative resistances of various kinds of bottles to acidic products at room temperature, if each kind of bottle tested has the same *size*, *shape*, and *storage history* as the corresponding bottles being considered for room-temperature service.

(4) Tests conducted with distilled water measure the resistances of glasses to solutions constantly increasing in alkali content. The rate of increase of alkali content of the solution is dependent on the glass composition. Such tests are related *only* to the resistance of glass bottles to *neutral*, *unbuffered* solutions.

(5) Relative resistances of glass bottles to extraction of alkali, as shown by test with distilled water at an elevated temperature, roughly parallel the relative resistances appearing in the storage of distilled water at room temperature *only* if the amounts of extracted material are approximately the same at both temperatures.

(6) The tendency of bottles to produce flakes in distilled water under given conditions must be considered as a probability. Only rough tests can be made unless a considerable number of each kind of bottle is subjected to identical conditions.

(7) There is no relation that holds for all glass-bottle compositions between the tendency of a bottle to form flakes when filled with distilled water or with an alkaline solution and the amount of soluble material extracted from the glass surface by distilled water or by such an alkaline solution.

(8) The most suitable method of comparing the resistances of glass bottles to the action of an alkaline product such as $N/50$ sodium hydroxide is the direct observation of the apparent quantities of insoluble matter produced on storage of the product.

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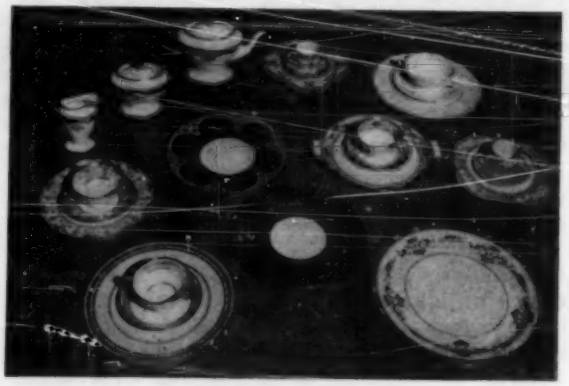

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Photographs of other exhibits in the executive offices of The Society were published in the 1940 issues of *The Bulletin* as follows: (1) Cincinnati Pottery Club and Porcelain League gifts, September, p. 353; (2) Overbeck Pottery, October, p. 407; (3) artware made by students of West Virginia in Smith-Hughes Extension Course, October, p. 407; (4) Porcelain League of Cincinnati, October, p. 408; (5) one of the five enclosed cases of exhibits, Franciscan pottery of Gladding, McBean & Co., and Vernonware of Vernon Kilns, November, *Advertising Section,* p. 24.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. Purdy, Editor

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Journal Reference: The journal name appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

January, 1941
20—1

Abrasives

Effect of the surface condition on some components of precision machines. L. Seletsky. *Schweis. Arch. Angew. Wiss. Tech.*, **5** [9] 267–72 (1939).—The usual methods of polishing surfaces are not accurate enough for precision machines. Lapping usually spoils the accuracy. Ball and roller bearings must be exact within 1μ and highly wear resisting. They cost 20 to 50 times as much as standard types. Their trueness is checked by optical means. Vees are best produced by scraping, not by grinding and polishing. Automatic fine polishing is used for precision rules, e.g., a standard meter. Marks are only 3 to 5 μ wide and usually just as deep; fine polishing, however, keeps them under 3 μ. A rule 1 m. long and 6 mm. widere quires 4 hr. for polishing with emery cloth (≈ 15 μ), 3 hr. for hand polishing, and 6 to 8 hr. for automatic fine polishing, i.e., 23 hr. for the square decimeter. J.M.N.

Grinding carbide cutters. F. W. Lucht. *Amer. Machinist*, **84** [17] 603–605; [18] 658–61 (1940).—L. discusses carbide grinding wheels for grinding milling cutters accurately and economically. The ideal grinding cycle for reconditioning a cutter requires the following types of wheels: (1) a silicon carbide plain wheel of about 80 grit for rough cylindrical grinding, (2) a 60-grit silicon carbide cup wheel with a 20° beveled face for rough back-off grinding, (3) a 120-grit silicon carbide cup wheel for finish grinding the carbide tip, and (4) a 220-grit, resinoid-bonded diamond wheel for finish grinding the carbide tip where the finish must be very smooth. Tables for clearances on milling cutters for different metals and the angles and tilts of the cutters are given together with complete directions for grinding procedure. M.H.

Grinding cracks in quenched steels. Anon. *Iron Age*, **145** [9] 44–45 (1940).—Because of their hardness, quenched steels are usually worked by grinding which often causes numerous hair cracks or "grinding cracks." Previous explanations have been as follows: (1) existing quenching cracks appear on the surface during grinding; (2) the mechanical shock of grinding cracks the brittle steel; and (3) heat caused by grinding is responsible. The present investigation indicates that (1) the cracks are caused by shrinkage of the thin surface layer of the material due to martensite transformation during grinding, (2) similar cracks may be produced by a very light surface tempering of the quenched material, and (3) to avoid cracks, quenched material should be tempered at above 150°C. (302°F.) to produce a beta-martensite structure before grinding. Proper selection of wheels is important. Cooling water is of little value, as wet and dry grinding are equally productive of cracks. E.H.McC.

Grinding of hardened gears. John C. Dixon. *Iron Age*, **145** [8] 29–32; [16] 49–52 (1940).—Modern gears require high precision in grinding. Two types of tooth-grinding machines are now manufactured. With the form-grinding type, the wheel is dressed to the desired profile; with the generating type, it is dressed or adjusted to the desired pressure angle. The equipment of various commercial manufacturers is illustrated and briefly described. E.H.McC.

Grinding and lapping machine. Anon. *Automobile Engr.*, **30** [396] 127 (1940).—A specially designed machine for grinding and lapping sintered carbide tools, e.g., either diamond impregnated or fine grade silicon carbide wheels, is described. M.B.H.

Measurement of flatness of polished surfaces. C. Tuttle and R. Cartwright. *Jour. Optical Soc. Amer.*, **30**, 348–50 (1940).—Two parallel beams of light are reflected by a sample through a cylindrical lens to form an astigmatic image of the source. If this image is a single line, the surface is flat within the accuracy of the instrument. Radii of curvature of the order of 40 ft. can be readily detected. An inspection device for testing glass to be used for photographic purposes is now in service. A.P.

Mounting of diamonds for turning and boring tools. Paul Grodzinski. *Engineering*, **147**, 418 (1939).—The brazing of diamonds into a holder has the following disadvantages: (1) the application of heat is apt to damage the cutting face; (2) the diamond may work loose due to shrinkage of the brazing metal; (3) the part of the diamond held by the brazing metal may be damaged. Low temperature alloys have not been used successfully. In

cold-setting methods it is not possible to machine the clamps to fit the natural faces of the diamond; this results in the high spots on the diamond forming the bearing surfaces. Ten types of cold-set (clamp) methods are described and illustrated. A ball seating is the most ideal method as stresses are distributed over a large area. Illustrated. B.C.R.

Natural and artificial abrasives used in the glass industry. O. Přidal. *Skláfské Rozhledy*, **16** [2] 24–28; [3] 45–54 (1939); abstracted in *Chem. Zentr.*, **1940, I**, 3440.—Comparison tests were made on natural and artificial abrasives. The grain size and constitution, appearance and coloring, specific grinding power, and decline in grinding power were tested on a grinding machine. Results are given. M.V.C.

Pickling and polishing of metals. Sam Tour. *Iron Age*, **145** [21] 56–60; [22] 26–30 (1940).—T. briefly touches on methods of mechanical polishing but presents a history of electropickling, still pickling, and electropolishing for the past 25 years, reviewing patents and articles. E.H.McC.

Polishing, cleaning, and finishing apparatus. Frank J. Oliver. *Iron Age*, **145** [16] 53–57 (1940).—New accessories of various manufacturers include a buffing lathe, a line of scratch brushes, and a new design of tilting-tumbling barrels. These are briefly described and illustrated. E.H.McC.

Reduction of silica and alumina. M. S. Maksimenko. *Metallurg*, **14** [4–5] 26–34 (1939).—On the basis of a literature review, M. draws the following conclusions. The silica is reduced at lower temperatures and with lower consumption of heat than alumina. The reactions apparently proceed as follows: $SiO_2 + 3C = SiC + 2CO$ and $SiO_2 + 2C = Si + 2CO$(FeSi). The Si or FeSi flows to a lower level in the reaction zone, and the SiC reduces the Al_2O_3 as follows: $Al_2O_3 + SiC = SiO_2 + 2Al + CO$. The freed SiO_2 again reacts with solid C. Practical suggestions are given for selecting the proper sizes of quartz and coke, for the right dosage of coke, and for the selection of an electric furnace. Two single-phase furnaces are compared: (1) a single-electrode furnace with a conducting bottom and (2) a two-electrode furnace. The second type is preferred. B.Z.K.

Simple rules for better grinds. H. C. Urbauer. *Amer. Machinist*, **84** [16] 567 (1940).—The production of high quality ground surfaces (plane or curved as in bearings) and of superior commercial finishes is economically possible by using standard grinders if the following five rules are observed: (1) the grinding wheel must be in perfect balance so that no vibration occurs; (2) grinder bearings must be tight and yet free enough to operate without heating; (3) the thinnest lubricating oil adaptable to the grinding machine operation should be used (this maintains cool running); (4) the cutting surface of the wheel must be kept clean and free from particles that may have become embedded in it during the roughing operation; (5) provisions should be made for filtering or otherwise removing particles of grit from the cooling solution so that none will be thrown between the wheel and the work on the last or polishing pass. To ascertain whether the surfaces are smooth enough a simple piece of copper is used as a gauge; it is scraped with a backward and forward movement across the ground surface parallel to the axis of the piece when all traces of oil have been removed and the piece is dry. If no copper dust is left on the piece or no frayed edges are produced on the gauge when the edge of the gauge is forced into the steel (or other material) the surface is smooth enough. This test method has proved highly satisfactory. M.H.

PATENTS

Abrading tool. N. H. Knowlton (United Shoe Machinery Corp.). U. S. 2,218,538, Oct. 22, 1940 (Oct. 4, 1937; Sept. 28, 1938). W. J. Tennant (American Optical Co.). Brit. 525,095, Sept. 4, 1940 (Feb. 16, 1939).

Abrasive article. C. E. Barnes (Norton Co.). U. S. 2,218,782, Oct. 22, 1940 (March 19, 1938).—An abrasive article comprises abrasive grains bonded by a synthetic resin containing styrene as the primary ingredient copolymerized with a substance of the group consisting of acrylic acid, alpha chloro-acrylic acid, and methacrylic acid.

Abrasive article and method of making. R. C. Benner and A. L. Ball (Carborundum Co.). U. S. 2,216,728, Oct. 8, 1940 (Dec. 31, 1935; renewed June 30, 1939).—The steps in the method of making an abrasive article comprise mixing diamond particles with powdered glass and a carbonaceous binder, heating up the mixture in an oxidizing atmosphere at temperatures below the melting point of the glass until the carbonaceous binder is substantially dissipated, heating the mixture in a reducing atmosphere until the glass is melted around the diamond particles, cooling the mass and crushing the cooled mass to form aggregates consisting of diamond particles and glass, and bonding the aggregates with a reactive resin under heat and pressure.

Abrasive element. Howard G. Bartling (Minnesota Mining & Mfg. Co.). Can. 391,265, Sept. 10, 1940 (Jan. 31, 1936). G.M.H.

Abrasive paper and process of making. N. E. Oglesby (Behr-Manning Corp.). U. S. 2,217,525, Oct. 8, 1940 (July 6, 1936).

Abrasive products and grindstones and other tools employing them. J. T. L. Gros. Brit. 525,494, Sept. 11, 1940 (Nov. 28, 1938).

Abrasive sheet. N. P. Robie (Carborundum Co.). Can. 391,635, Oct. 1, 1940 (Nov. 28, 1938). G.M.H.

Abrasive sheet material. H. G. Bartling and E. B. Overshiner (Minnesota Mining & Mfg. Co.). U. S. 2,220,140, Nov. 5, 1940 (Jan. 29, 1929; March 15, 1933).

Adhesive sheet or tape material. Durex Abrasives, Ltd., and C. H. Corwin. Brit. 527,298, Oct. 16, 1940 (March 30, 1939).

Automatic multiple crankpin grinding machine. H. F. Klingele (Landis Tool Co.). U. S. 21,582, Sept. 24, 1940 (Aug. 14, 1936); reissue of original 2,014,768, Sept. 17, 1935.

Bit grinding jig. P. R. Francis (Alloy Steel & Metals Co.). U. S. 2,215,694, Sept. 24, 1940 (May 4, 1938).

Bonded granular ceramic article. L. H. Milligan and R. H. Lombard (Norton Co.). Can. 391,117, Sept. 3, 1940 (Sept. 16, 1936; in U. S. Sept. 28, 1935). Can. 391,118, Sept. 3, 1940 (Oct. 14, 1937; in U. S. Nov. 21, 1936). G.M.H.

Buffing machine. N. H. Knowlton (United Shoe Machinery Co.). U. S. 2,218,537, Oct. 22, 1940 (Oct. 4, 1937).

Buffing wheel. H. E. Hargy, Sr. U. S. 2,215,522, Sept. 24, 1940 (May 2, 1940).

Carburized silica. C. Alfred Jacobson (Sealco By-Products Co.). Can. 390,381, July 30, 1940 (Dec. 20, 1938). G.M.H.

Coated abrasive sheet. Nicholas E. Oglesby, Charles F. Reilly, and Victor W. Gilbert (Behr-Manning Corp.). Can. 391,338, Sept. 17, 1940 (Oct. 16, 1937; in U. S. Feb. 6, 1937). G.M.H.

Composite abrasive sheet. A. L. Ball (Carborundum Co.). Can. 390,143, July 23, 1940 (June 11, 1938). G.M.H.

Crank grinding machine. C. L. Ott and R. E. Price (Landis Tool Co.). U. S. 2,220,490, Nov. 5, 1940 (Dec. 5, 1935).

Crush-forming operations on grinding wheels. Coventry Gauge & Tool Co., Ltd., S. J. Harley, and J. E. Wainwright. Brit. 526,075, Sept. 25, 1940 (March 8, 1939).

Cutting-off wheel. Duane E. Webster (Norton Co.). Can. 389,911, July 9, 1940 (March 26, 1938; in U. S. March 30, 1937). G.M.H.

Cylindrical grinding machine. H. S. Indge (Norton Co.). U. S. 2,220,768, Nov. 5, 1940 (March 9, 1938).

Drill sharpener attachment. G. K. Guenther. U. S. 2,217,545, Oct. 8, 1940 (July 6, 1939).

Gear lapping apparatus. J. M. Christman (Packard Motor Car Co.). U. S. 2,215,750, Sept. 24, 1940 (Nov. 30, 1936).

Grinding and abrading machine. Sidney Adolph Horstmann. Can. 389,682, July 2, 1940 (July 7, 1938). G.M.H.

Grinding machine. H. E. BALSIGER (Landis Tool Co.). U. S. 2,220,471, Nov. 5, 1940 (Oct. 7, 1938).

Grinding machine for injection needles. HACHIRO ENYA. U. S. 2,215,752, Sept. 24, 1940 (June 23, 1939).

Grinding machine for internal threads. FERNAND TURRETTINI (Société Genevoise d'Instruments de Physique). U. S. 2,218,775, Oct. 22, 1940 (Dec. 14, 1938).

Grinding machinery. C. I. LOTT. U. S. 2,219,425, Oct. 29, 1940 (Jan. 8, 1938).—A continuous centerless grinding machine for angle grinding the ends of cylindrical members.

Grinding wheel. HERBERT W. WAGNER AND KENNETH F. WHITCOMB (Norton Co.). Can. 391,387, Sept. 17, 1940 (Aug. 1, 1938). G.M.H.

Grinding wheel dust hood. T. F. ESERKALN AND R. E. GROBE (Kearney & Trecker Corp.). U. S. 2,219,444, Oct. 29, 1940 (Dec. 2, 1937).

Holder for grinding drills. OLCOTT HASKELL. U. S. 2,220,326, Nov. 5, 1940 (Feb. 12, 1940).

Hydraulically operated grinding machine. C. G. FLYGARE (Norton Co.). U. S. 2,217,618, Oct. 8, 1940 (April 28, 1939).

Machine for grinding cutter blades, particularly gear cutters. GLEASON WORKS. Brit. 525,743, Sept. 18, 1940 (June 29, 1938).

Machine for making sandpaper, etc. WALKER BURNS (Behr-Manning Corp.). U. S. 2,217,247, Oct. 8, 1940 (July 7, 1930).

Making abrasive articles. S. S. KISTLER AND C. E. BARNES (Norton Co.). U. S. 2,218,795, Oct. 22, 1940 (Jan. 28, 1938).—A method of making an abrasive body consists in placing in an open mold the size of the finished article just enough loose uncoated abrasive grain to form the article, pouring a polymerizable compound which is fluid at room temperatures onto the abrasive grain in the mold, heating and without pressure thereby polymerizing the compound around the abrasive grains to a hard condition to form the final abrasive body in the mold, and stripping the abrasive body from the mold.

Manufacture of abrasive articles. E. T. RAINIER (United States Rubber Co.). U. S. 2,216,135, Oct. 1, 1940 (May 21, 1937).—An abrasive grinding wheel, the abrasive grains of which are united by means of an organic bond selected from the class consisting of vulcanized hard rubber and hardened phenol-aldehyde resins having incorporated therein an anhydrous, water-soluble inorganic salt of a metal of the class consisting of the alkali metals and alkaline-earth metals, the salt having a melting point within the range of 700° to 1200°C.

Means for shaping and truing the operating surfaces of grinding wheels used for form grinding. S. J. HARLEY. U. S. 2,220,647, Nov. 5, 1940 (July 17, 1939).

Method and apparatus for facing tools with an abrasive element. F. W. ROLLAND. Brit. 526,241, Sept. 25, 1940 (Feb. 11, 1939).

Method and devices or tools for truing grinding worms. REISHAUER-WERKZEUGE AKT.-GES. AND A. RICKENMANN. Brit. 525,932, Sept. 18, 1940 (March 3, 1939).

Method and machine for polishing articles. I. J. GRUENBERG (Gear Grinding Machine Co.). U. S. 2,218,353, Oct. 15, 1940 (May 22, 1939).

Method and means for balancing grinding wheels. E. C. BALLMAN. U. S. 2,216,308, Oct. 1, 1940 (Oct. 10, 1938).

Method and means for manufacture of abrasive cloth. C. F. HILL (Westinghouse Electric & Mfg. Co.). U. S. 2,217,444, Oct. 8, 1940 (April 6, 1938).

Precision grinding of contoured articles. R. H. CRAMER (General Motors Corp.). U. S. 2,218,982, Oct. 22, 1940 (Nov. 16, 1936).

Production of abrasive material. F. J. TONE (Carborundum Co.). U. S. 2,219,853, Oct. 29, 1940 (Dec. 31, 1935).—A coated article is relatively stiff and rigid in its own plane but is capable of being repeatedly flexed by the application of lateral pressure.

Production of articles with highly polished surfaces. L. SCHACHERL. Brit. 527,347, Oct. 16, 1940 (Sept. 30, 1938).

Segmental pulp wheel. G. B. RICKARD AND H. P. KIRCHNER (Carborundum Co.). U. S. 2,219,398, Oct. 29, 1940 (Feb. 9, 1938).

Sheet abrasive. F. G. OKIE (Minnesota Mining & Mfg. Co.). U. S. 2,219,278, Oct. 22, 1940 (April 28, 1933; June 13, 1938).

Sheet abrasive and method of making. F. G. OKIE (Minnesota Mining & Mfg. Co.). U. S. 2,219,263, Oct. 22, 1940 (Feb. 6, 1929; April 28, 1933; renewed Oct. 25, 1939).

Silicon carbide abrasive articles. W. J. TENNANT (Carborundum Co.). Brit. 526,130, Sept. 25, 1940 (March 8, 1939).

Surfacing sheets of zinc or copper or other metals. T. J. MASSE (Edes Mfg. Co.). U. S. 2,216,539, Oct. 1, 1940 (July 28, 1939).

Synthetic grindstones. R. BOYLE. Brit. 526,325, Sept. 25, 1940 (March 13, 1939).

Art and Archeology

America's first potters. E. R. HARRINGTON. *Ceram. Age*, **36** [2] 41–43 (1940).—H. briefly describes the making of pottery by the Pueblo Indians of New Mexico. Illustrated. F.G.H.

Anglo-Netherlandish goblet. E. B. HAYNES. *Connoisseur*, **106** [468] 64–65 (1940).—H. discusses his research on this recently discovered glass and its importance in furnishing a link between groups of Anglo-Netherlandish glasses of 1660 to 1680. On the combined evidence of stem type, bowl form, and the characteristics of the metal, he assigns it to the period very near 1680. Illustrated. M.E.P.

Antiquities from the Indus Valley. ANON. *Brit. Museum Quarterly*, **14** [2] 41–42 (1940).—Specimens in the British Museum of prehistoric pottery from Perians-Ghundai and Dabar-kot in Northern Baluchistan and Mohenjo-daro are described. The ware consists of decorated and undecorated pottery, figurines, pottery wheels for model carts, and brick. A.B.S.

Baltimore Museum of Art. ANON. *Bull. Amer. Ceram. Soc.*, **19** [10] 416–17 (1940).

Beginnings of civilization in eastern Asia. C. W. BISHOP. *Antiquity*, **14**, 301 (1940).—Civilization in eastern Asia began in the Neolithic Age, probably as a result of contacts with the northern portions of both the Old and New Worlds. Neolithic pottery was unglazed coiled ware; it survived in China far into the historical period. The Late Neolithic sites yield the famous Chinese painted ware (decorated in red, black, and white) of about 3000 B.C. This was followed by smooth black earthenware, made on the wheel, which was of fine texture and finish. From 2000 to 1050 B.C. was a Dark Age, followed by the Bronze Age in which primitive ware was gradually replaced by better ware. A.B.S.

Bird's-eye view in stained glass of the Middle Ages. J. HELBIG. *Jour. Brit. Soc. Master Glass Painters*, **7**, 110–15 (1937–1938).—H. concludes, from numerous examples, that the portraying of architecture in stained glass as if seen by a bird in flight was transmitted from the Byzantine miniature by way of Germany. This supports the J. L. Fisher theory that glass painting originated with Byzantine civilization and that Benedictine houses of the Danube were the chief agents of transmission. M.B.H.

Ceramic colors. CAMPBELL ROBERTSON. *Ceram. Age*, **36** [2] 37–40, 48–49 (1940).—R. assumes that the problems of design, harmony, and hues have been specified and then reviews the practical means of bringing about the desired effects upon ceramic ware in a manner to satisfy simultaneously (1) the designer, in regard to quality and attractiveness of shades and appearance, (2) the plant

superintendent (stability and ability to withstand adverse production conditions), (3) the general manager (cost), and (4) the color manufacturer (practicability and reproducibility of production). *Ibid.*, [3] 71–74, 80.—The formulation, manufacture, testing, and application of both raw and vitrified pigments are briefly described. F.G.H.

Chinese art. FRANK DAVIS. *Illus. London News*, **105** [2731] 356 (1939).—Two red porcelain bowls trimmed with ormolu, a porcelain vase of the K'ang Hsi reign, and two pottery figures from a tomb of the T'ang dynasty are illustrated. L.F.M.

Chinese ceramics. ANON. *Illus. London News*, **105** [2729] 276 (1939).—The Victoria and Albert Museum has acquired two Chinese jars of stoneware (3rd century B.C.) and a black-glazed earthenware vase of the Tz'u Chow type from the Sung dynasty. Illustrated. L.F.M.

Chinese porcelains at Cleveland Museum of Art. ANON. *Ceram. Age*, **35** [1] 11 (1940).—A page of illustrations is presented. F.G.H.

Contemporary American industrial art at Metropolitan Museum of Art. ANON. *Ceram. Age*, **36** [1] 9 (1940).—Ceramic exhibits are illustrated. F.G.H.

Cucuteni painted ceramics. RADU VULPE. *Illus. London News*, **194** [5226] 1123–25 (1939).—At Calu, all the principal styles of the Cucuteni Neolithic culture of Moldavia are divided into three phases: "Cucuteni A," represented by pots painted in white, red, and black with spiral or meander motifs; "Cucuteni B trichromic," represented by ornaments painted in the same colors but with the spaces of the design often filled in with hatching; and "Cucuteni B dichromic," represented by geometrical ornaments on the plain surface of the pot. At Izvoare a new layer at the base of the Cucuteni layer was discovered. It is characterized by monochrome ceramics, gypsum incrustations, grooves or moldings in relief, and lines of dots imprinted upon the clay while soft by means of a toothed comb. This is similar to the "Kammkeramik," the Neolithic period of Russia and Siberia. Illustrated. L.F.M.

Danish porcelain. ARTHUR HAYDEN. *Connoisseur*, **106** [468] 54–59 (1940).—A spasmodic attempt was made to found a factory under Louis Fournier (1760 to 1766); the real factory, however, began with Frantz Heinrich Müller in 1775. Queen Juliane Marie suggested the mark of three blue lines signifying the three waterways of Denmark. In 1779 it became the Royal Copenhagen Factory, the name it still bears. The great period of Müller, which culminated with the manufacture of the famous service for Catherine II of Russia at the last of the 18th century (*Ceram. Abs.*, **18** [6] 145; [8] 201 (1939)), was known for its rich overglaze painting and gilding. At the beginning of the 19th century, the British Fleet at war caused considerable damage in the Sound, and the products of the factory at this time show the wartime influence in the decorative motifs and designs. In 1888 Copenhagen set a new style, underglaze painting, which many Continental factories have since copied. The famous Danish pattern in blue and white was developed under Arnold Krog ("Copenhagen . . . ," *ibid.*, **19** [1] 4 (1940)). Under him too came the development of figurines of national characteristics, Danish peasantry modeled with reticence and painted in the soft colors of the underglaze palette. Other ceramic sculptors of this factory include Gotfred Rode, V. M. Fischer, C. F. Liisberg, Gerhard Henning, and Malinowsky. The firm of Bing and Grondahl (*B & G*) also contributed to Danish porcelain art. Illustrated. M.E.P.

Danish pottery and glass at New York World's Fair. ANON. *Ceram. Age*, **34** [4] 110–11 (1939).—Characteristic ware is described. Illustrated. See "Contemporary . . . ," *Ceram. Abs.*, **19** [11] 251 (1940). F.G.H.

Decalcomania: proposed development. ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **23** [11] 341–42 (1940).—1 reference.

Fifth Ceramic Exposition at Rutgers University. ANON. *Ceram. Age*, **36** [1] 13–15 (1940).—The scope and purpose of the exhibit are described and illustrated. F.G.H.

Leaded lights and ornamental glazing: I. J. A. KNOWLES. *Jour. Brit. Soc. Master Glass Painters*, **7**, 134–38 (1937).—K. describes methods of window making prior to the use of glass. Boards pierced with holes were often used, and such materials as paper, parchment, and linen, rendered translucent by coating with oil or varnish, were stretched on frames. As late as the 17th century, only the upper parts of hall windows were glazed. Illustrated. Thirteen references. **II.** *Ibid.*, pp. 184–91. **III.** *Ibid.*, **8**, 18–25 (1939).—K. describes the history of origination, use, and decoration of the quarry or lozenge shaped window. Illustrated. Nine references. M.B.H.

Medieval heraldic glass in Surrey churches: I. F. SYDNEY EDEN. *Connoisseur*, **106** [467] 7–9 (1940).—Less than thirty of the more than 200 coats of arms in stained glass listed from this region date from before the 16th century. Several are described and illustrated. M.E.P.

Military subjects on Russian Imperial porcelain. H. COMSTOCK. *Connoisseur*, **105** [466] 262 (1940) —Most of the plates from the Russian Imperial Factory in the 19th century which the Schaffer Galleries are showing depict military subjects. C. describes their colors and Empire motifs. See "Porcelain bowl . . . ," *Ceram. Abs.*, **18** [8] 202 (1939). M.E.P.

Mosaic art revived in New Jersey. ANON. *Ceram. Age*, **36** [4] 103–104 (1940).—Experimental mosaic tile work as conducted by the Work Projects Administration of New Jersey is briefly described. Illustrated. F.G.H.

Mycenean vases. THEODORE LESLIE SHEAR. *Illus. London News*, **105** [2726] 161–62 (1939).—Mycenean vases were found in the royal tomb at Athens by the American school. The upper parts of the amphoras are decorated with a nautilus, a scale pattern, and painted spirals. The decorative effect is enhanced by the use of bright red upon the buff ground. Illustrated. See "American archeologists . . . ," *Ceram. Abs.*, **18** [4] 92 (1939); "Treasury . . . ," this issue, p. 5. L.F.M.

Ninth Annual National Ceramic Exhibition. ANON. *Bull. Amer. Ceram. Soc.*, **19** [11] 453–55 (1940).—Illustrated.

Oriental art at Philadelphia Museum. HELEN COMSTOCK. *Connoisseur*, **106** [467] 33 (1940).—Four notable architectural features in this exhibit of Persian, Indian, and Chinese art are described. Walls from a 16th century Sunni monastery at Isfahan are of glazed earthenware tile of turquoise and peacock blue and black and show the Islamic characteristic of incorporating color into architecture. M.E.P.

Origin of the "Tithe Pig" pottery group. H. BOSWELL LANCASTER. *Connoisseur*, **105** [466] 253–55 (1940).—Illustrating with a Derby porcelain figurine group, probably modeled after a pottery original by Ralph Wood, L. tells of the simple country ballad which inspired a number of characters often portrayed by the potter. This story is found on a mug decorated and signed by John Sadler. The characters are the vicar, the farmer, his wife, the pig, and the child. The "Vicar and Moses" (1784), the sequel to the "Tithe Pig" ballad, is also appropriately characterized by Toby jugs and figurine groups. Illustrated. M.E.P.

Old Chelsea. ANON. *Ceram. Age*, **35** [3] 83, 88–89 (1940).—The history of Chelsea porcelain is briefly reviewed. F.G.H.

Origins of designs on old Chelsea porcelain. BELLAMY GARDNER. *Connoisseur*, **106** [467] 3–6 (1940).—G. has traced the source of many of the designs gathered by Nicholas Sprimont during his directorship of the Chelsea factory. The examples cited include (1) a Chelsea white-glazed bust, $4^1/_2$ in. high, of the Duke of Cumberland, which was made in 1750 and was copied directly from a medal struck to commemorate his victory at the battle of Culloden, 1746; (2) one of a set of gold anchor Chelsea figures of Italian comedy which resembles a Murillo painting; and (3) a pair of gold anchor Chelsea vases, panel decorated in color with figures from Jacques Callot drawings of the Balli di Sfessania. Illustrated. M.E.P.

Padua Hills ceramic studio. HOWARD R. ERWIN. *Ceram. Age*, **34** [4] 105–106 (1939).—E. describes the production on a small scale of artistically designed ware for the display of flowers. Illustrated. F.G.H.

Pre-Columbian Andean art: I, Periods and styles. PHILIP AINSWORTH MEANS. *Magazine of Art*, **33** [9] 510–15 (1940).—M. gives a survey of Andean art from the geographical and chronological viewpoints. The various styles and periods are profusely illustrated with pottery forms and designs. M.E.P.

Slip house layout for Jet and Rockingham production. R. B. BLOORE. *Trans. Brit. Ceram. Soc.*, **39** [6] 178–81 (1940).—B. describes a plant using red clay for its product. R.A.H.

Stained glass. History and appreciation. C. NORRIS. *Jour. Brit. Soc. Master Glass Painters*, **7**, 120–30 (1937–1938).—From 125 to 1500, glassmen strived for the perfect combination in stained glass, rich color and adequate light. Cooler colors and the new discovery, silver stain, were introduced. N. describes the new color schemes, the use of silver nitrate, sulfate, or chloride to give gold shades, and the painting technique of that period. See *Ceram. Abs.*, **17** [11] 347 (1938). M.B.H.

Stained glass in the Chapel of the Holy Blood at Bruges. BERNARD RACKHAM. *Jour. Brit. Soc. Master Glass Painters*, **8**, 45–50 (1939–1940).—The original windows were made in 1483. The present windows were executed by Pluys of Malines between 1845 and 1847. The originals were removed during the French Revolution; after being lost for years, some were traced and bought by the Victoria and Albert Museum in 1910. The heraldic panels of these eleven windows are described. M.B.H.

Treasury of Atreus. A. B. WALL. *Antiquity*, **14**, 233–49 (1940).—W. gives a brief illustrated description of three-legged cooking pots and vases with spiral decorations which were among the contents of nine beehive-shaped tombs of the Bronze Age (*circa* 1350 B.C.) in Mycenae (Greece); see "Mycenean. . . ," p. 4. A.B.S.

Trends in dinnerware. ANON. *Ceram. Age*, **35** [5] 149 (1940).—A page of illustrations is presented. F.G.H.

BOOKS

Irish Art in the Early Christian Period. FRANÇOISE HENRY. Methuen & Co., Ltd., London. Price 25s. Reviewed in *Times Lit. Supp.*, **39** [2009] 370 (1940).—H. gives a coherent account of Irish art from the prehistoric pagan period to the 10th century, dealing with architecture, sculpture, and antiquities. The book is of deep interest to the general reader as well as to the student of art and architecture. Illustrated. K.W.W.B.

Temples of Armant. Preliminary Survey. ROBERT MOND AND OLIVER H. MYERS. Egypt Exploration Society. 2 vols. Price 63s. Reviewed in *Times Lit. Supp.*, **39** [2016] 487 (1940).—The fragmentary remains of the many temples at Armant (Hermonthis) erected to the god Menthu, are described. Technical reports by specialists are included. K.W.W.B.

Twenty Centuries of Mexican Art. Museum of Modern Art, New York. Price $2.75. Reviewed in *Times Lit. Supp.*, **39** [2018] 499 (1940).—A record of a recent exhibition held by the Museum in cooperation with the Mexican Government is presented. Illustrated. K.W.W.B.

PATENTS

Decalcomania transfer. BENJAMIN ASNES (Dennison Mfg. Co.). U. S. 2,216,289, Oct. 1, 1940 (Dec. 10, 1938).—Decalcomania material of the type comprising a backing, a layer of starch sizing on the backing, a separable design, and intermediate adhesive temporarily holding the design on the layer, characterized in that the adhesive comprises two strata, a dextrin coating having a high degree of solubility to afford quick separation of the design and a gelatin coating having a relatively low degree of solubility and being located between the dextrin stratum and the design so as to remain substantially intact with the design when the dextrin stratum is dissolved, thereby assuring both quick separation and ample adhesive for mounting the design.

Decalcomania transfer. LLOYD V. CASTO (Oxford Varnish Corp.). Can. 391,831, Oct. 8, 1940 (Dec. 13, 1937; in U. S. July 31, 1935). G.M.H.

Designs for:

Bottle. GREEN SPOT., INC. Can. 12,858, Sept. 14,1940.
KIK CO. Can. 12,812, July 4, 1940. G.M.H.
Cookstove. A. G. SHERMAN (Globe American Corp.). U. S. 123,437, Nov. 5, 1940 (March 30, 1940).
Diffusing light reflector. W. B. PETZOLD (General Electric Co.). U. S. 122,878, Oct. 1, 1940 (June 20, 1940).
Glass grape dish. A. H. NICHOLSON (Federal Glass Co.). U. S. 123,060, Oct. 15, 1940 (Sept. 6, 1940).
Glass hurricane lamp. A. H. NICHOLSON (Federal Glass Co.). U. S. 122,877, Oct. 1, 1940 (Aug. 14, 1940).
Glass pineapple dish. BELLE KOGAN (Federal Glass Co.). U. S. 123,056, Oct. 15, 1940 (Aug. 30, 1940).
Glass tumbler. A. H. NICHOLSON (Federal Glass Co.). U. S. 122,691, Sept. 24, 1940 (July 22, 1940).
Goblet. C. W. CARLSON. U. S. 122,766 to 122,769, Oct. 1, 1940 (July 19, 1940). E. W. FUERST (Libbey Glass Co.). U. S. 122,924, Oct. 8, 1940 (Jan. 26, 1940).
Stove. R. G. RUTLEDGE. U. S. 123,327, Oct. 29, 1940 (March 4, 1940).
Vase. C. W. CARLSON (United States Glass Co.). U. S. 122,765, Oct. 1, 1940 (Feb. 9, 1940).

Cements

Burning mechanism in the rotary cement kiln: I, Research plan. T. YOSHII. *Jour. Soc. Chem. Ind. Japan*, **42** [4] 261–64 (1939); Supp. Binding, pp. 151–54B.—Many researches which have been carried out under different conditions cannot account for the true feature of the burning mechanism in the rotary cement kiln. In the practical kiln commercial clinker sinters at about 1450°C. within a few minutes, while in the test kiln a much higher temperature and a longer time are required. Even in similar kilns, the results are irrational and indistinct. Y. therefore made a thorough investigation of this mechanism by physical, chemical, thermodynamic, thermochemical, and petrographic methods, resorting to microscopic and X-ray investigation. **II, Sampling of the raw meal.** *Ibid.*, pp. 264–66; Supp. Binding, pp. 154–56B.—To investigate the actual burning mechanism in the working rotary cement kiln, a large sample should be taken out through many holes previously provided on the kiln shell. To avoid perforation of the shell, a special sampler for the front parts of the kiln and a special method of sampling from the remaining parts are applied. When the kiln is shut down and cooled, the surface crust is easily quenched, the ignition loss in that portion being nearly equal to the kiln content under the running condition. From samples from the surface crust, therefore, the actual state of raw meal in the running kiln can be safely visualized. To secure strict accuracy of measurement, however, some corrections must be taken into account in regard to the distance from the kiln inlet to the respective sampling points, i.e., $P_{x+0.8(\infty)}$ (for a dry kiln) and $P_{x+0.8(\infty)}$ (for a wet kiln) must be adopted instead of the actual distance to the sampling point P_x. **III, X-ray analysis of cement raw meal.** *Ibid.*, [9] 615–17; Supp. Binding, pp. 304–305B.—Y. made an X-ray analysis of cement raw meal in a rotary kiln using the Debye-Scherrer method. Six or seven samples were taken from each drying, preheating, calcining, sintering, and cooling zone of wet and dry kilns, the sampling method being the same as that described in Part II. The standard minerals such as $3CaO \cdot SiO_2$, $2CaO \cdot SiO_2$, γ-$2CaO \cdot SiO_2$, $3CaO \cdot Al_2O_3$, $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$, MgO, and CaO were employed for the comparison. The results were as follows: in dry and wet processes, the diffraction line of limestone was present in samples for 70% of the length of the kiln. Following this region the lines of free

lime appeared. Finally X-ray spectra of alite and belite were observed; those of celite were observed indistinctly. In the X-ray photograph of flue dust, many lines were observed for limestone and free lime, and the presence of a small amount of belite was confirmed. Y. concluded, therefore, that the dust escaped not only from the preheating zone but also from the sintering zone, and minute nuclei of belite are formed before the clinkering appears. These results of X-ray analysis are concordant with results of the following microscopical and chemical investigations. **IV, Microscopical examination of the raw meal.** *Ibid.*, pp. 617–19; Supp. Binding, pp. 305–308B.—A microscopical examination was made of limestone, clayey substance and purple ore, and quartz particles as the raw materials. The alite, belite, and celite present in the clinker were also examined. The refractive index, double refraction, cleavage, and other optical properties and the crystallographic characters were studied. **V.** *Ibid.*, pp. 619–24; Supp. Binding, pp. 308–13B.—Raw meals both in dry and wet kilns were carefully observed under the microscope in accordance with the results shown in diagrams. The dehydration of the clay first occurs and then the thermal decomposition of limestone takes place. Belite appears next, then celite, and finally alite. Low-calcium silicates such as $CaO \cdot SiO_2$ were not observed. The development of alite is rapid after the disappearance of the free lime. The transformation of belite to alite is due to the exhaustion of the free lime produced by the decomposition of $3CaO \cdot Al_2O_3$ which was previously prepared (I). From these results, it is clear that the change of belite to alite continues, to a certain extent, until the clinkered mass which has passed the highest temperature zone is completely cooled. Sudden cooling of the clinker should be prevented for the satisfactory development of alite. Better clinker depends more on the cooling condition than on the duration of heating. Y. also shows the necessity of grinding the clay finer than limestone and of disintegrating the quartz particles. M.T.

Characteristics of Portland cement. L. D. ERSHOV. *Prom. Stroitel. Materialov*, **2** [2] 32–37 (1940).—The intensity of the processes of increase of the mechanical strength with time can be expressed by a modulus of intensity, i.e., the ratio of the alite content to the belite content percentages in Portland cement clinker. This modulus (*Mi*), for quick-hardening cement with high initial strength, should be equal to or should exceed 3.0. Typical belite cements must have an intensity modulus not exceeding 0.5. The amount of heat evolved during the hardening process should be expressed by an exothermic modulus (*Me*) changing in a direct relation to the ratio alite + $3CaO \cdot Al_2O_3$: belite + brownmillerite. Low-heat cement evolving under 70 cal. per gm. after 28 days should have an exothermic modulus not exceeding 0.33. At *Me* = 0.35 to 1.8, the heat evolved is 70 to 100 cal. per gm.; at *Me* exceeding 1.8, it exceeds 100 cal. per gm. P.B. & E.S.

Increasing the mechanical strength of brick. L. M. BLYUMEN. *Prom. Stroitel. Materialov*, 2 [4–5] 93–95 (1940).—The mechanical strength of brick was greatly increased by the addition of up to 7% of cupola furnace slag. P.B. & E.S.

Low-heat cement. H. L. LEHMAN AND E. L. ERICKSON. *Eng. News-Record*, **125** [11] 97 (1940).—Cracking of the concrete in the piers and roadway slab of the Baton Rouge bridge was reduced to a minimum by the use of a modified Portland cement of the low-heat type in which the calcium aluminate is limited to 7% and the ratio of iron oxide to alumina is limited to 1.50. B.C.R.

Nature of glass in Portland cement clinker. HERBERT INSLEY. *Jour. Research Nat. Bur. Standards*, **25** [3] 295–300 (1940); RP. 1324. Price 10¢.—I. describes a method of etching the polished surfaces of Portland cement clinker with KOH solution which permits the detection of glass containing considerable iron hitherto overlooked in microscopical examination. The results of quantitative microscopical analysis using this technique are reported and compared with the results obtained by an older method. The later results are practically identical with earlier results for clinkers with Al_2O_3/Fe_2O_3 ratios greater than 2.00, but for those with ratios less than 2.00, they give more glass and less $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ than the earlier results. The quantitative results for glass by the later microscopical technique are more nearly in agreement with the results by an independent method involving the determination of heat of solution. R.A.H.

Pozzuolanic Portland cement. ANON. *Concrete & Constructional Eng.*, **35** [3] 117–18 (1940).—The resistance to sea water of concrete structures made with pozzuolanic Portland cement is briefly discussed. See "Composition . . .," *Ceram. Abs.*, **18** [11] 291 (1939). F.G.H.

Properties of pozzuolana. ANON. *Concrete & Constructional Eng.*, **33** [11] 540 (1938).—Various theories regarding the resistance of pozzuolanic cements to attack by chemical agents are briefly discussed. F.G.H.

Role of iron in Portland cement. GABRIEL A. ASHKENAZI. *Pit & Quarry*, **33** [1] 63–65, 67 (1940).—A review is given. A.G.S.

Samples of gypsum from N'Gobevu, Natal. J. LEVIN. *Minerals Research Lab. S. Africa Bull.*, No. 5, pp. 25–37 (1940).—L. describes the various laboratory methods attempted for purifying lump gypsum which occurs in Natal. V. L. Bosazza found that the boulder gypsum is sporadically distributed in red and blue clays similar to those of the Port Elizabeth area. The clays are very fine grained and do not disperse easily owing to the solution of calcium sulfate. L. details some washing tests and discusses the disadvantages. Froth flotation was also attempted in one experiment but was abandoned as it was considered unsatisfactory. Chemical and physical data are given for various samples of plaster of Paris. The paper is one of the most important on South African plaster of Paris preparation. V.L.B.

Theories and specifications for Portland cement. P. H. BATES. *Pit & Quarry*, **33** [3] 37–40, 49 (1940). A.G.S.

Use of sodium alginate in waterproofing cement and concrete. P. G. PIGACHE. *Concrete & Constructional Eng.*, **34** [7] 402–403 (1939).—Details of the composition are given. F.G.H.

Use of special cements in large dams in the United States. B. HELLSTRÖM. *Concrete & Constructional Eng.*, **35** [4] 191–98 (1940).—"Low heat" cement has, to a great extent, replaced ordinary Portland cement and "moderate heat" cement in the construction of dams in the U. S. Little is known as yet about Portland pozzuolanic cement, but it is now attracting great attention. Illustrated. F.G.H.

PATENTS

Cementitious material. D. S. HUBBELL (H. H. Robertson Co.). U. S. 2,218,679, Oct. 22, 1940 (June 9, 1938).—A nonporous cementitious material possessing improved weather and water resistance comprises a magnesium oxychloride cement containing finely divided metallic material in an amount substantially less than the amount of the cement, the metallic material comprising in part finely divided copper and in part finely divided lead.

Control of setting period of gypsum plasters. P. L. MENAUL. U. S. 2,216,207, Oct. 1, 1940 (Feb. 11, 1939).—A composition of matter: powdered plaster of Paris intermixed with a relatively minute proportion of sodium hexametaphosphate.

Enamel

Acid pickling. R. SAXTON. *Sheet Metal Ind.*, **13**, 763–64 (1939).—HCl is sometimes used as a preliminary pickle, but 6 to 8% H_2SO_4 is generally used. Prior to tinning, two pickles are required: the first removes foreign matter from the surface and gives an etched, nonoxidized surface for good bonding, and the second is a white pickle used after annealing (1.5 to 3% H_2SO_4 at 60°C.). Electropickling is more expensive but gives a better finish with

lower acid consumption. Stainless sheets require different solutions. Inhibitors are now almost universally used. A new electrolytic pickle uses fused Na salts with the material to be cleaned connected as the cathode. Nascent Na is liberated, which reduces the oxides to metallic Fe. The advantages of this method are as follows: (1) there is no material loss, (2) there is no H_2 embrittlement, (3) pickling can be combined with heat treatment or stress relieving if Na salts of suitable melting points are used, and (4) cleaned sheets are less likely to corrode than sheets given an acid pickle. A.P.S.

Application of enamel. G. S. LINDSEY. *Emaillerie*, 7 [4] 20–21; [5] 11–13; [6] 11–19; [7] 13–15; [8] 8–15; [9] 7–8 (1939).—L. discusses the technique under the following headings: (*A*) *Dipping:* (1) proportion of water in the slip, (2) suspension agents, (3) dipping sheet metal, (4) control of consistency of the slip, (5) action of the neutralization solution on draining, (6) weight of enamel dry and weight of enamel wet, (7) draining dipped articles, (8) conveyers, (9) retouching, (10) cooling vats with circulation of water. (*B*) *Application of enamel with spray gun:* (1) distribution of air, (2) eliminating and recovering excess enamel in booths, (3) continuous and automatic spraying, (4) pressure reservoirs, (5) care of gun, (6) spraying cast iron, (7) spraying sheet metal, (8) one coat enameling, (9) applying black border enamels with a spray gun. M.V.C.

Castings for enameling. J. A. DONALDSON. *Foundry Trade Jour.*, 61 [1217] 405–407 (1939).—Castings free from sections uneven in thickness (such as heavy ribs, bosses, door catches, hinges, etc.) are desired for enameling purposes. If projections do occur on the underside they should be of the same depth. The composition should be of a type to give a close-grained gray fracture, high density, and good mechanical strength. Gates should be located on the edge of the casting, and if the casting is of unequal section the gate should be set at the thinner part since this arrangement will lessen the tendency of the casting to warp. Runners should be broad, and their thickness should be tapered to as thin a section as possible at points where they meet the casting so that any dirt from the gate may be trapped. H.E.S.

Chemistry of pickling. G. BATTA AND E. LECLERC. *Chimie & Industrie*, 41 [Special No.] 292–96 (April, 1939); *Jour. Iron & Steel Inst.*, 141 [1] 28A (1940).—The chemical actions which occur in the pickling process are studied. The metal to be cleaned, the material to be removed, and the reaction products are dealt with. The action of inhibitors is also discussed.

Chemistry and vitreous enamels. EMERSON P. POSTE. *Ind. Eng. Chem.*, 32 [1] 9–15 (1940).—The sheet-iron base for vitreous enamels should contain less than 0.20% carbon. To prepare sheet iron for enameling a 6% solution of sulfuric acid at a temperature of about 150°F. is used for pickling. The iron content of the pickling bath is carefully watched, and the bath is discarded when the concentration of solids reaches 6%. Neutralization of the ware after pickling and prior to enamel application is necessary to prevent rusting and to present a chemical surface condition that is properly related to the enamel being used. Weak, hot solutions of soda ash or mixtures of soda ash and borax are in common use, though various excellent proprietary compounds are on the market. A nickel dip after pickling prevents many enameling troubles. The ware is given a nickel "flash" by immersion in a bath containing 3 oz. per gal. of nickel sulfate ($NiSO_4 \cdot 6H_2O$) and 0.25 oz. per gal. of boric acid. The control of pH within a range of 5.5 to 6.0, varying somewhat from one case to another, is essential. The bath is operated at a temperature range of 150° to 180°F. and the time of treatment is usually about 5 min. P. briefly describes the chemical raw materials used in enamel compositions and emphasizes the importance of enamel-slip consistency in its application to various types of ware. He also discusses firing of enameled products, adherence of enamel to sheet steel, developments in opacity of acid-resistant enamels, and uses of vitreous enameled products in the chemical industries. Illustrated. F.G.H.

Cleaning polished steel. J. S. BRADY. *Steel*, 105, 62–63, 71 (Oct. 9, 1939).—B. describes an electrocleaning process (reverse-current cleaning) for cleaning polished steel which will remove all types of oil, dirt, and all traces of smut and polishing compound which cannot be removed by the usual cleaning methods. The material is to be used at a concentration of 8 oz. per gal.; the temperature should be 200°F., current density 40 amperes per sq. ft., and time 30 sec. No wiping or brushing is necessary after cleaning, and no preliminary cleaning is needed. Greater economies in manufacture and increased speed of cleaning are also claimed for this cleaner. H.E.S.

Commercial possibilities of bagasse-furnace slag. B. R. DAS GUPTA, B. K. MUKHERJI, AND H. N. DAS GUPTA. *Indian Ceramics*, 2 [1] 9–14 (1939).—When bagasse is burned in a step-grate furnace, a spongy fused mass having superimposed layers of different coloration is deposited on the bridge walls and hearth walls. The feasibility of using this slag as the principal ingredient in the ceramic industry is studied. It has a specific gravity of 1.9 and a hardness of 4 to 5 and sinters at 1225°C. The chemical analysis is given in the following table:

	Slag (%)	Bagasse (%)
SiO_2	73.40	81.80
Al_2O_3	2.81	1.07
Fe_2O_3	1.60	2.19
CaO	2.50	2.91
MgO	4.70	3.89
K_2O } Na_2O }	13.41	5.20
MnO	0.15	0.25
P_2O_5	1.32	2.60
Total	99.89	99.91

Successful tests were made on the suitability of the powdered slag for ground-coat material. It can advantageously replace feldspar and quartz. Fritting can also be avoided when the slag is used. The following compositions were found very satisfactory for mild steel. The enameled sheets withstood the hammering test and were free from enamel defects.

	Composition (parts by weight)					Duration of firing (min.)	Temperature of firing (°C.)
No.	Slag	Red lead	Calcined borax	White lead	Magnesia		
1	20	7				3.5	920
2	20	5	1			3.5	900
3	20	6	1			3	900
4	20	6	1		0.25	3.5	900
5	20	5	2		0.20	3	900
6	30		8		0.50	4	930
7	30		9		0.35	3	900
8	30		6	3	0.25	3	910

The inherent opacity of the slag suggested its use simultaneously in cover enamel. No difficulty was experienced in the preparation of blue, black, and yellow frits. The compositions suitable for this purpose are given in the following table:

		Composition (parts by weight)							
No.	Color	Slag	Pb_3O_4	Borax	MgO	KNO_3	Soda ash	Sb_2O_3	Coloring oxide
1	Yellow	20	7	2	1		1	1	
2	Yellow	20	7	25	1.5		1.5	1.5	
3	Blue	20		5		1	3	1	0.5
4	Blue	20		4	0.5	1	3	1	0.5
5	Black	20	4	5		1	2.5		0.5
6	Black	20	5	4		1	2.5		0.8

Each frit was ground with 1.5% white china clay. Occasional difficulty in spreading capacity was remedied by the addition of magnesia in the mill mixture.

Because of its excess iron content the slag cannot be used in the manufacture of special types of glass but only

as one of the principal ingredients of bottle glass. Use of slag in the batch mixture will also reduce manufacturing cost. The presence of manganese oxide in the slag, even in small quantities, improves the tone of the color of the resultant glass in spite of the excess iron oxide; alumina improves the quality of the glass, and potash improves its brilliance. A.P.S.

Construction of degreasing vats. A. H. HAESSLER. *Emaillerie*, **7** [1] 17–20 (1939).—H. describes the construction of a degreasing vat which assures maximum efficiency. The dimensions of the vat should be sufficiently large to accommodate the carrier and completely submerge all pieces. The best method of heating is by steam-heated coils placed along one side of the vat. The length of pipe and dimensions can be determined by the aid of the table given. The piping is covered by a protective screen having rows of perforations along the top. This arrangement forms a thermosiphon and is the best means of preventing deposits from settling on the pieces; it sets up violent convection currents in the solution which agitate the bath and float the scum to the opposite side of the vat where it can be skimmed off. The steam inlet valve is placed at the bottom of the vat, and the outlet valve, with a steam trap to prevent waste and to maintain pressure, is placed at the top. The condensation water can be returned to the boilers, or, if the water of the region is hard, it can be used in the degreasing vat, provided no harmful ingredients are present. A thermometer should be placed about $^2/_3$ up the wall opposite the coils where it can be easily read. Illustrated. M.V.C.

Correct use of the term "porcelain." ANON. *Gas Age*, **85** [7] 34 (1940).—According to a recent decision of the Porcelain Enamel Institute, the words "porcelain" and "porcelain enamel" may be used interchangeably when applied to products which are technically described as a vitreous or glassy finish applied to a metal shape. Manufacturers of organic finishes are not justified in using the term "porcelain" in referring to their products, and they should not use such misleading terms as "porcelain-like," "as durable as porcelain," "feels like porcelain," etc. B.C.R.

Deformation and flowability tests of molding sands. R. CHADWICK. *Foundry Trade Jour.*, **62** [1242] 416 (1940).—C. presents the following conclusions with regard to deformation and flowability of molding sands: (1) there is a definite relation between the flowability and deformation; (2) these properties are most easily controlled by varying the clay content or the moisture content; (3) the flowability test is most useful in the control of hardness; a sand having low flowability would require greater ramming effort, and a hard mold surface having a low permeability would be the result; and (4) to obtain the fullest information, the deformation should be recorded at intervals as the increased load is applied to the test piece, and the results obtained should be plotted by means of a graph. H.E.S.

Degreasing of metal parts. H. G. H. CROWTHER. *Metal Ind.* [London], **56** [2] 23–25 (1940).—The reaction between the degreasant solution and the work to be cleaned, involving wetting power, interfacial tension, emulsification, deflocculation, and rinsability, is pointed out. The cleaning may be accomplished by one of the following methods: (*a*) immersion for a given time in the hot degreasant solution and then rinsing, (*b*) electrolytic cleaning, and (*c*) treatment in an automatic machine wherein the solution is sprayed on the work. Electrolytic cleaning is recommended, in which the tank is charged with a 5% solution of degreasant using a voltage of six and about 50 amperes per sq. ft. of work. Either anodic or cathodic cleaning may be practiced. The efficiency of cleaning is based upon (*a*) time of contact, (*b*) temperature of degreasant solution, and (*c*) concentration of degreasant solution. In order to check the thoroughness of cleaning the following test is recommended: Dissolve 2 gm. of basic fuchsin in 10 cc. of carbolic acid, warming to assist solution; add 100 cc. of glycerine to the mixture and stir well; add 200 cc. of distilled water and again stir well; allow the stain to run over the whole surface and put aside for 5 min.; rinse out with fresh water. Any grease remaining will be revealed by the pink stain on the metal surface. H.E.S.

Determination of the resistance to acids of enamels. GERHARD SCHMIDT. *Glashütte*, **70** [25] 313–15 (1940).—The stability of acidproof enamel on metal to the action of corrosive chemical agents depends on the resistance to mechanical wear as well as on the chemical resistivity of the enamel; these factors are in turn conditioned by the physicochemical structure of the enamels and the manner in which the latter come in contact with the attacking agents. An enamel with a high resistance to acids may lose more weight in an acid-solubility test, because of pores, cracks, or other defects, than a less acid-resistant enamel in the same length of time. The measurement of the loss-in-weight figure for a certain period of time is not sufficient for the accurate determination of the acid solubility of an enamel; the dependence on time of the loss-in-weight figure must be brought into consideration. If a series of tests covering different periods of time are made, the figures for the loss in weight are represented graphically (the horizontal values representing the time and the vertical values the loss in weight), and these points are joined by a line, a solubility curve of an enamel in a corrosive agent is obtained. Values can be calculated mathematically which characterize the action of the acid on the given enamel exactly. In this way it can be determined that the quantity of enamel dissolved out by an acid increases logarithmically with the time; the rate of dissolving is inversely proportional to the time of dissolving, or the rate of dissolving slows down with longer dissolving time. This holds true for the separate constituents dissolved out as well as for their sum (the total loss in weight of the enamel). A graph shows the curves for the different components of an enamel and the total. The mathematical law may be expressed by the formula $x = 2.3 \times a \times \log (1 + c \times t)$, where $x =$ quantity of enamel dissolved out in time t drawn from the unit of surface and a and c are constants; they characterize the acid resistivity of the enamel tested. To make them clearer, the processes occurring during dissolving are reviewed as follows: Some components (sodium oxide) dissolve out more readily than others (silicic acid). Soon after the attack begins, a layer is formed which contains more silicic acid and less sodium and is therefore more resistant, although the surface is now rough and pitted; this condition permits acid to penetrate to the layers beneath and thus to continue the attack but with diminishing intensity. It is not the quantity of enamel dissolved out in a single given period of time but the figures a and c that determine the acid stability of an enamel. The constant a is proportional to the sum of the forces producing the dissolving (approximately the difference between the solubility pressure and binding force); c measures the conductivity of the amounts diffusing out of the enamel into the acid. The greater a and c are, the lower is the acid resistance of the enamel and vice versa. The effect of a on the quantity dissolved is greater than that of c. The constant a may be called the acid-resistance figure. In calculating a, however, c must first be ascertained. Formulas for computing c and a are given and are illustrated by an example. An enamel may be said to be resistant to a given acid if the acid-resistance figure is less than 0.4 mgm. per cm.^{2} after treatment with boiling acid. An enamel is classified as highly resistant if the acid-resistance figure, a, is less than 0.4 mgm. per cm.^{2} after treatment with 20% boiling HCl. Theoretically, the enamel will not be destroyed by acid alone, but the fact that the enamel surface is pitted and roughened causes it to be more easily knocked off by mechanical wear and rubbing. The resistant layer is thus removed, and the soluble parts are again exposed to the acid attack. This process continues until the enamel is completely destroyed. Pores and cracks in the enamel hasten the process. M.V.C.

Drying enamel. R. R. SHERRILL. *Emaillerie*, **7** [9] 15 (1939); **8** [1] 7–12, 17–18 (1940).—Although the drying of enamels is as important in enamel production as firing and may be the cause of numerous flaws in the enamel, it is still done empirically. Every problem of

drying should be studied theoretically and in practice. The heat necessary for drying enameled objects exercises three functions: (1) promotes evaporation of moisture on the surface of the enamel, (2) aids in drawing molecules of water within the enamel through its pores to the surface, and (3) augments the evacuation capacity of the surrounding air. This evacuation capacity of air is limited, but it may be increased by the circulation of the air. Until the drying process is completed, the water should be uniformly distributed throughout the thickness of the enamel layer because, if the rate of evaporation at the surface is more rapid than that of the arrival of the water from within the enamel to the surface, the surface tends to dry and contract. Only the last trace of moisture should pass through the enamel as steam; it is probable that this cannot be extracted in any drier but will remain until the piece is fired. Drying in the open air is a fairly uniform process, but it is slow and may permit the metal to rust. Modern methods of manufacture require rapid drying, which is achieved successfully by the rapid circulation of moist warm air in the drier. The moisture in the air prevents too rapid drying, especially of the surface. The rapidity of the drying process is conditioned by the speed at which water in the enamel traverses the capillaries and reaches the surface; there is little that can be done to improve capillary phenomena except to grind and prepare the enamel particles carefully. Most defects in drying (shrinkage, waving, and spalling) result from attempts to accelerate the drying process. Although the conditions necessary for obtaining rapid and correct drying are known, it is difficult to maintain and control these conditions in enamel driers. Up to the present time, no rule has been advanced for the permissible humidity of the air in the drier, and no automatic control mechanism has yet been perfected. Every drier presents a different problem. Instruments for determining the humidity give some assistance, however, and these should be used. There are many types of chamber driers; these accommodate pieces of different shapes and sizes and serve as a repository for the enameled pieces until they can be fired. They are insulated and dustproof. The continuous drier is a heated chamber through which the enameled pieces are transported by conveyers at a speed appropriate for maintaining the right conditions for drying. There are other types of driers which simplify operations. Practically any method of heating can be used for all driers. Circulating air containing water steam is better than the direct radiation of heat as it minimizes the risk of burning. If coal is used as fuel in the combustion chamber, the ware must be protected from dust and cinders. Oil is not expensive and is comparatively clean. Gas is also clean and well adapted for heating driers. The waste heat from the furnace can be utilized by installing recuperators, and it is an inexpensive and efficient source of heat for driers. Electricity provides the ideal heat. It may be used for direct radiation or in ventilators which circulate hot air over the ware; it can also be salvaged from an electric furnace where the heat escapes above the conveyer chains. The new method of heating by induction of heat has not been extensively used for enamel, but it is an excellent means of drying enamel throughout its entire thickness. Further tests will probably be made on this method. M.V.C.

Effect of superheating on castability and physical properties of cast irons of different carbon contents. N. A. ZIEGLER AND H. W. NORTHRUP. *Trans. Amer. Foundrymen's Assn.*, **47**, 620–52 (1939). H.E.S.

Enameling on precious metals. W. E. CHARLES. *Foundry Trade Jour.*, **62** [1242] 421–22, 424 (1940).—The composition of jewelry enamel closely resembles that of flint glass of which the finest tableware is made and which is capable, with various adjustments, of adhering to and decorating certain metals such as gold, silver, copper, and platinum. The enamels usually consist of sand, red lead, borax, and soda, and they vary in fusibility according to the metal on which they are fused. The coloring oxides are similar to those used for coloring glass. Different styles of enameling include cloisonné, champlevé, *basse-taille*, *au jour*, and Limoges. H.E.S.

History of mill-addition opacifiers in vitreous enameling. H. D. PRIOR. *Bull. Amer. Ceram. Soc.*, **19** [10] 379–83 (1940).—25 references.

Influence of climatic conditions on enameling. B. DEUTSCH. *Foundry Trade Jour.*, **62** [1220] 12–15 (1940).—The changing temperature and humidity in the atmosphere caused by climatic conditions affect the various processes in the manufacture of enameled products. The amount of hydrogen passing through iron during pickling is rapidly increased at higher temperatures, and thus the possibility of defects due to hydrogen entrapped in the iron (blistering, boiling, reboiling, and certain kinds of fish-scaling) is greater with increasing pickling bath temperature. During milling, increased temperature increases the amount of soluble salts and thus affects the fluidity and consistency of the enamel. Similar effects are noted when the aging temperature of the enamel is increased. Climatic conditions greatly influence the drying of enameled ware unless the drier is the type in which the temperature, humidity, and air circulation are all controlled automatically according to changes in climatic conditions. The firing process, especially in continuous furnaces, is greatly influenced by the amount of moisture in the firing zone. A moisture content of 10% by volume causes blistering, copperheading, and poor surface texture. D. recommends measures which will protect the enamel against the influence of extreme weather conditions. H.E.S.

Materials used to render glass, glazes, and enamels opaque. E. BÜTTNER. *Farben-Chem.*, **9**, 162, 169 (1938); *Chem. Abs.*, **33**, 3549 (1939).—B. reviews methods using sulfides of Zn or Sb, Ca phosphates, oxides of Ti, Sn, Zn, Zr, Ce, or As, certain F compounds, or large proportions of MgO, kaolin, etc.

Plating iron for enameling. ANON. *Manchester Guardian Commercial*, **36** [927] 275 (1938).—Microscopic examination shows that enamel ground coatings on lightly nickel-plated iron have excellent adhesion. The nickel layer retards the rate of oxidation in the scale-forming period. Of the three processes, viz., etching with oxidizing acid solution, sandblasting, and nickel-plating, the last is the most practical. The process is inexpensive. Temperature control, time of immersion, and regulation of pH are the most important factors. F.J.H.

Porcelain enameled ticket stations on new Pennsylvania turnpike. ANON. *Ceram. Age*, **36** [3] 69–70, 80 (1940).—Details of the design and construction are presented. Illustrated. F.G.H.

Principles of enameling of cast iron. G. T. O. MARTIN. *Foundry Trade Jour.*, **62** [1233] 260–64; [1237] 331–36 (1940).—M. discusses the effects of (1) the metal, (2) the enamel, and (3) the application process. H.E.S.

Properties and characteristics of enameling iron. JOSEPH C. ECKEL AND JOHN A. ECKEL. *Bull. Amer. Ceram. Soc.*, **19** [11] 419–23 (1940).—Illustrated.

Scientific approach to a foundry problem. L. A. DANSE. *Trans. Amer. Foundrymen's Assn.*, **47**, 147–78 (1939).—D. discusses the chronic cracking of castings as encountered from 1912 to 1939. Design and planning and control of this trouble are discussed in general, while methods used to determine the causes are described in detail. The results of placing thermocouples in various positions in the core and mold are given. Interpretations of the various cooling curves are also included. H.E.S.

Surface films in metal cleaning. E. C. RINKER. *Metal Ind.* [London], **56** [8] 195–96 (1940).—R. discusses the various types of films encountered in the cleaning of metals. They include films of mineral oils, greases, soap, fatty acids, and solid particles. The recommended practice for their removal is given. H.E.S.

Synthetic molding sand. A. TIPPER. *Foundry Trade Jour.*, **62** [1225] 119–22 (1940).—The advantages and disadvantages of synthetic sand are given. **Discussion.** BUCKLAND ET AL. *Ibid.*, [1226] 131. H.E.S.

Tests on effectiveness of water blast under high pressure for cleaning castings. RONALD WEBSTER. *Trans. Amer. Foundrymen's Assn.*, **47**, 909–24 (1939).—W. discusses the cleaning of castings by means of water blasting. Tests are outlined which cover the specific effect of water at high

velocity against steel as compared with the effect of water at the same and lower velocities when mixed with abrasive. Photographs and charts of the results of the tests are included. H.E.S.

Two coats of enamel or three. L. VIELHABER. *Emailwaren-Ind.*, **14** [27] 191–92 (1937).—Two ways of reducing the customary three applications of enamel on sheet metal to two coats include (1) the use of a ground and only one cover coat instead of two cover coats, and (2) the omission of the ground coat. There is little economy in the first method because such great care must be taken in applying the single cover coat and in firing and the enamel layer must be thicker or contain more opacifier. Difficulties are also encountered in the second case. There are white ground enamels with good adherence for sheet metal, but they must be applied uniformly or thin places will appear dark; the cover coat does not conceal these places. White ground enamels must not have much dissolving action on the metal oxides or they will become darkened. The removal of all impurities from the surface of the metal and the fine-grained roughening of the surface to permit a good mechanical adherence are the requirements for satisfactory results. M.V.C.

Value of the electrolytic stripper to the finishing shop. E. E. HALLS. *Sheet Metal Ind.*, **13**, 249–50 (1939).—H. presents the experimental results in the development of an electrolytic method of de-painting and de-enameling. This method, if properly laid out, is convenient in operation, and when used in conjunction with a conveyerized enameling shop, it proves successful and economic. The caustic soda process forms the basis of the electrocleaning process which has been worked out to minimize the disadvantages of the former. A range of solutions was prepared for comparison, and results are incorporated in the table below. The most satisfactory composition is No. 5. H. gives a schedule of stripping times in electrostrippers with high voltage 100 amp. d. c. per sq. ft. All specimens consist of three coats of stove-black enamel on steel.

	Composition of alkali cleanser (oz. per gal. of water)				
No.	Caustic soda	Tri-sodium phos-phate	Sodium meta-silicate	Time for complete strip-ping (min.)	Remarks
1	0	80	0		Only half stripped in 10 min.
2	32	0	1½	3	
3	80	6	1½	2	Solution tended to splutter
4	32	6	1½	5	
5	80	40	10	1½	

A.P.S.

Water supply for enamel plants. J. T. IRWIN. *Emaillerie*, **6** [11] 23–25; [12] 7–11 (1938).—The composition and purity of the water used in wet enameling affect the quality of the enameled articles. The chemical and physical properties of water vary according to the differing geological constitution of the terrain from which it is derived. Rain is the purest natural state of water but it contains some gases, microbes, and dust absorbed from the air. Rain which sinks into the ground to different depths is called subterranean water and is obtained from wells, springs, etc. It contains minerals in solution, sometimes in high concentrations, and may also contain injurious gases. Rain water which runs off the surface directly into streams and rivers is called surface water; it holds sand and other particles in suspension and some mineral salts and organic matter in solution. The amount varies with the rainfall. Water purified in filtration plants may also contain a large amount of mineral impurities. Water for washing, rinsing, pickling, and neutralizing solutions must be as free of mineral salts as possible. Rain water, distilled water, and filtered surface water are best for washing as they require less soap and form less of the viscous precipitates. Boiling and siphoning waters that are not too hard will precipitate some of the impurities so that such water can also be used; water softeners must be used for hard waters. Soft water is preferred for pickling in order to prevent any precipitation of lime salts on the metal, which will cause imperfections in the enamel (bubbles or copperheads). Neutralizing solutions are kept slightly alkaline and contain alkaline products, principally sodium carbonate; if hard water is used for the solutions, some of the neutralizing compounds are absorbed in the softening of the water and precipitates adhering to the pieces will cause similar flaws. The water should therefore be changed more frequently than softer waters, or filter presses should be used to purify the water. M.V.C.

SEPARATE PUBLICATION

Half a Millenium of Porcelain Enameling. FERRO ENAMEL CORP. RESEARCH STAFF. Ferro Enamel Corp., Cleveland, 1940. 15 pp. Free.—The development of raw materials used in the manufacture of cover-coat porcelain enamels is traced. 17 references.

PATENT

Process for vitreous enameling. A. L. MATTHES (Bomat, Inc.). U. S. 2,216,017, Sept. 24, 1940 (Sept. 9, 1938).—A method of making vitreous enameled articles on a metal base by the wet enameling process comprises the steps of preparing the ceramic coating material and coloring oxide by grinding it to a dispersoid fineness of substantially one-tenth micron or less, mixing the coating material and the oxide with a suitable vehicle, applying a design-forming coating of the material and oxide to the metal base, drying the applied coating at a temperature below the flash point of the coating material and for a sufficient time to evaporate materials in the coating to prevent formation of gases at higher temperatures, applying another and different color design-forming coat to the base so that at least some of the later applied coat will be superimposed on an earlier applied coat, drying the later applied coat, and firing the coatings to vitrify and bond them to the base metal and to each other.

Glass

Bibliography of literature on the chemical durability of glass (1934 to 1939). *Glass Ind.*, **20** [9] 328–30 (1939).—66 references. A.P.

Brashear Centennial. ANON. *Bull. Amer. Ceram. Soc.*, **19** [11] 444–49 (1940).—3 references.

Briquetting glass batch. ANON. *Sprechsaal*, **72** [26] 349 (1939); translated in *Glass Ind.*, **20** [9] 337 (1939).—Three replies are given to the question "Does the briquetting of batch still find practical application and what are the advantages and disadvantages?" **American viewpoint.** F. G. SCHWALBE. *Ibid.*, pp. 337–38. A.P.

British optical industry's raw materials. ANON. *Optician*, **99** [2566] 269–73 (1940).—A survey is given of the raw materials for the optical glass manufacturing industry. Prior to Sept., 1939, the majority of lenses were imported. M.B.H.

Colored glasses. M. FANDERLIK. *Sklářské Rozhledy*, **13** [4] 56–58 (1936); abstracted in *Referat. Silikatliteratur*, **5** [2] 4909 (1938).—Glass may be colored by (1) the colored atoms of metals or metal oxides (this is similar to colored salt solutions), (2) the formation of microscopic or ultramicroscopic colored crystals, (3) the formation of groups similar to the organic chromophoric groups, and (4) the colloidal distribution of particles of metal or other elements. The physical explanation of the coloring of glass is that the normal white light rays passing through the glass are broken up and some of the rays are absorbed; if, for example, a glass absorbs the yellow rays and the other rays pass through, then the yellow rays are absent from the light shining through the glass. In this case the glass appears to be the complementary color to that absorbed by the glass, viz., violet. Two complementary

colors striking the eye at the same time make white or give the impression of white light. The color of a glass, therefore, depends on the absorption of a given color of the spectrum. The glass may absorb light rays of different wave length and at different intensities. The first method of coloring glass is not conditioned by the changes of the temperature of the glass during the working processes (cooling, annealing, etc.) but is dependent on the composition of the batch. The other three methods are dependent on the heat-treatment of the glass. M.V.C.

Colored mirrors. BRUNO SCHWEIG. *Glass*, **17** [8] 246; [9] 284 (1940).—S. gives methods and formulas for producing colored mirrors in which colored metallic compounds or metals provide the reflecting surface. The lead sulfide process for producing a gray-blue and several formulas for making gold mirrors are mentioned. In the latter process the use of a recently developed organic gold compound (acetyl acetone diethyl gold) is discussed. This compound, not yet obtainable commercially, is soluble in organic solvents such as alcohol but not in water. One of its desirable properties is that the thickness of the gold film may be calculated fairly accurately in advance, thus making it of possible use for preparing gold films for scientific instruments. S. discusses several formulas for preparing copper mirrors, in which the reducing agents are formaldehyde, phenylhydrazine, and hydrazine sulfate. See "History...," *Ceram. Abs.*, **19** [10] 233 (1940). B.C.R.

Constants of metallic oxides in the vitreous state. ERNST KORDES. *Fortschr. Mineral., Krist., & Petrog.*, **22**, XLV (1937); *Neues Jahrb. Mineral. Geol.*, Ref. I, **1938**, 201; *Chem. Abs.*, **33**, 3091 (1939).—By extrapolation to zero of the other constituent of the values of n and density for glasses containing BaO and TiO_2, the values of these constants for BaO and TiO_2 in the vitreous state were deduced. Those of As_2O_3 were directly determined. The results together with those connecting n and density for glasses containing B_2O_3 and one or more of ZnO, CdO, PbO, and Sb_2O_3 are tabulated.

Continuous production of vitreous silica and high-melting glass in the shape of rods and tubes. W. HÄNLEIN. *Z. Tech. Physik*, **21**, 97–101 (1940).—A method has been developed for producing at a very rapid rate tubing and solid rod of vitreous silica and glass of high melting point. A tungsten furnace used contains a crucible made from molybdenum from which the material is drawn. Illustrated. W.M.C.

Corning Glass Works aids in developing a glass pump. CORNING GLASS WORKS. *Nat. Glass Budget*, **55** [11] 3, 10 (1939).—Handling of commercial quantities of corrosive acids and chemical fluids is possible with the new glass pump. This pump is of the centrifugal type, in which the pumping action is secured from the force of the rotating liquid. The casing, the rotating impeller, and all parts in contact with the corrosive liquid are of clear, chemical-resistant glass. The rotor is accurately balanced and runs at high speed without appreciable vibration; the pump readily handles 6000 gallons of acid or other liquid and will deliver it 70 ft. above the suction level. H.E.S.

Correcting the firing of a tank furnace with defective recuperator by analysis of flue gases. ANON. *Glashütte*, **70** [26] 325–26 (1940).—The flue gases of a tank furnace were analyzed to determine why the furnace could no longer be maintained at the proper temperature. Samples of flue gas taken at different points in the recuperative system showed that excess air had been leaking in at some point. An examination of the recuperator masonry disclosed a rupture in the canal system which was caused by slag corrosion. When the break was filled up with grog, the furnace soon regained its former efficiency and the right temperature. The steps of this investigation are presented to show how the cause of similar difficulties in other tank furnaces can be traced and how the firing of a defective furnace can be controlled and corrected by studying the values obtained from the analysis of the flue gases. M.V.C.

Czechoslovak lining glasses. O. PŘIDAL. *Sklářské Rozhledy* **13** [7–8] 113–19 (1936); *Chem. Zentr.*, **1937, I**, 1999–2000; *Chem. Abs.*, **32**, 7230 (1938).—Thorough testing of the properties of such glasses showed that at a bending strength of 337.9 kgm. per sq. cm. a high resistance to impact (the dropping of a steel sphere) was shown. Comparison with glazed ceramic slabs indicated the glass coatings to be superior. The glass adheres well to a cement base and is readily cut and worked. The chemical resistance is high.

Decolorization of manganese and sulfur in glass with application to use of furnace slags. A. E. BADGER. *Glass Ind.*, **20** [6] 231–33 (1939).—Zinc sulfide or cadmium sulfide additions to the batch prevent purple coloration by trivalent manganese. Excess ZnS produces amber colors, while excess CdS causes a canary-yellow color. Slags color glasses amber or black because of their content of sulfur, manganese, and iron. Zinc oxide additions prevent coloring by sulfur and manganese. The amber color produced by 5% slag in a glass batch may also be prevented by the use of arsenic or antimony oxides. A.P.

Decolorization of southern Illinois silica. J. S. MACHIN AND F. V. TOOLEY. *Illinois State Geol. Survey, Rept. Investigations*, No. 47, pp. 5–35 (1937); *Chem. Abs.*, **32**, 4738 (1938).—Decolorization involves Fe removal, and possible methods are listed as high-temperature methods, wet leaching with acids alone or in the presence of reducing agents, and electrical or magnetic separation of Fe compounds. Experimental investigations of three wet-leaching methods employing HCl or H_2SO_4 or a combination of an active metal with $NaHSO_3$ and H_2SO_4 indicate that it is feasible to bleach by any of the three methods.

Densities of soda-lime-silica glasses: V, Densities of glasses with 73 to 80% SiO_2 and 1 to 7% CaO. I. SAWAI AND S. INOUE. *Jour. Soc. Chem. Ind. Japan*, **42** [5] 286–89 (1939); Supp. Binding, pp. 160–61B.—Na_2O-CaO-SiO_2 glasses in this range were measured at 25° to 1200°C. at intervals of about 50°C. Curves showing the relation between the temperature and the mean specific gravity of annealed samples were obtained. The composition and the change at high temperature were also studied. **VI, Densities of glasses with 70% SiO_2 and 8 to 13% CaO.** *Ibid.*, [10] 699–701; Supp. Binding, pp. 331–32B.—Experiments were made on glasses whose compositions are nearly in the range of actual technical glasses. Methods and examinations are similar to those described in Part V. **VII, Densities of glasses with 71% SiO_2 and 8 to 12% CaO.** *Ibid.*, pp. 701–703; Supp. Binding, pp. 331–32B. **VIII, Densities of glasses with 72% SiO_2 and 10 to 13% CaO.** *Ibid.*, pp. 703–704; Supp. Binding, pp. 331–32B. **IX, Criticism on the measurement of density by Badger and Harman, especially near 1300°C.** *Ibid.*, [12] 881–84; Supp. Binding, pp. 407–409B.—The specific gravity-temperature curves of glasses in the system CaO–Na_2O–SiO_2 show sharp inclinations at about 500° to 600°C. in each case. According to the measurements of A. E. Badger and C. G. Harman (*Ceram. Abs.*, **18** [3] 71 (1939)), founded on the modification of the maximum bubble pressure method (*ibid.*, **17** [8] 275 (1938)) and calculated from it, smooth curves were obtained. The authors prepared three samples in order to examine the continuous change in density from room temperature to 1300°C. by Hänlein's method (*ibid.*, **11** [6] 355 (1932)) and by a method adapted from Stokes' law, especially at 1300°C. These results also show a sudden change in the curve near 500° to 600°C. and not a straight line as reported by Badger. The curves obtained by Hänlein's method coincide with those obtained by Stokes' method. **X, Densities of glasses with 71 to 72% SiO_2 and 15 to 20% CaO.** *Jour. Soc. Chem. Ind. Japan*, **43** [2] 84–86 (1940); Supp. Binding, pp. 47–49B.—Powdered samples were examined from 25°C. up. Measurements were made at high and low temperatures. Between 900° and 1200°C., the samples all devitrified. **XI, Densities of glasses with 73 to 74% SiO_2 and 7 to 14% CaO.** *Ibid.*, pp. 87–89; Supp. Binding, pp. 47–49B.—Above 900°C. some glasses had devitrified too much to be examined, but others could be measured up to 1200°C. **XII, Densities of glasses with 75% SiO_2 and 10 to 15% CaO.** *Ibid.*, pp. 89–90; Supp. Binding, pp. 47–49B.—These glasses were similarly measured. Al-

most all of them began to devitrify at 900°C. **XIII, Densities of glasses with 76 to 77% SiO_2 and 7 to 16% CaO.** *Ibid.*, pp. 90–92; Supp. Binding, pp. 47–49B.—Devitrification occurs at 850°C. in general, and measurements failed. **XIV, Densities of glasses with 78% SiO_2 and 8 to 14% CaO.** *Ibid.*, pp. 92–93; Supp. Binding, pp. 47–49B. **XV, Densities of glasses with 79 to 81% SiO_2 and 7 to 13% CaO.** *Ibid.*, pp. 93–95; Supp. Binding, pp. 47–49B.—Above 800°C. examinations were not made owing to devitrification. According to results reported in Parts **X** to **XV**, every curve showing the relation between specific gravity and temperature has the smooth inclined curvature, and there is never one straight line. The difference in the densities of annealed and quenched samples is negligible. For Part **IV** see *Ceram. Abs.*, **19** [3] 62 (1940). M.T.

Development and manufacture of optical glass in America. M. H. Eisenhart and E. W. Melson. *Sci. Monthly*, **50** [4] 323–34 (1940).—The development and manufacture of optical glass as the result of the World War in 1917 are traced and illustrated. The development of new crown and flint glasses to produce a greater variation between refractive index and dispersion is described. Improvements in manufacture such as better and purer glass pots for melting, mechanical stirring, annealing, and improved furnaces are pointed out. H.E.S.

Discussion on thermal endurance of glass containers. J. B. Murgatroyd. *Jour. Amer. Ceram. Soc.*, **23** [11] 328–29 (1940); see *ibid.*, [4] 119–21. **Reply.** F. W. Preston. *Ibid.*, [11] 329.

Elimination of surface reflections. Anon. *Optician*, **99** [2561] 189 (1940).—Research on surface films on lenses which increase the light transmission is described. The surface film is claimed to have a lower index of refraction than the original glass. M.B.H.

Face-lifting with structural glass. Earl Aiken. *Mfrs. Record*, **109** [6] 26 (1940).—Various applications of glass block, glass-faced masonry, and heat-absorbing glass are described. B.C.R.

Glass containing cadmium sulfide: I. K. Fuwa and H. Inuzuka. *Jour. Soc. Chem. Ind. Japan*, **42** [9] 601–603 (1939); Supp. Binding, p. 296B.—When cadmium sulfide is added to a glass batch, a yellow glass will result. CdS compound must be one of the constituents of the glass. X-ray analysis shows the clear lines of α-CdS when the glass is heated at a constant moderate temperature; they disappear again at a high temperature (1200°C.). The colorization of glass depends on the heating temperature. In other words, α-CdS exists in the glass, and the suspension of the α-CdS particles changes its state by peptization or coagulation, causing the color of the glass to change. M.T.

Glass molds present many problems. Robert M. Scafe. *Foundry*, **68** [8] 30–31, 103–105; [9] 36, 101–103 (1940).—S. discusses many of the complex problems involved in the production of cast-iron molds for glassmaking. Illustrated. F.G.H.

Glass painter, Mathias Dortmund. Louise von Winterfield. *Jour. Brit. Soc. Master Glass Painters*, **7**, 116–19 (1937–1938).—In an endeavor to determine the painter of an important painted glass specimen, W. found material which throws some interesting sidelights on the artistic relations between Dortmund, Cologne, and Soest. M.B.H.

Glass from reh. R. Charan and M. L. Misra. *Science & Culture*, **4** [9] 513–15 (1939).—Sand, lime, and soda ash are the chief raw materials for the manufacture of glass in India. The first two occur abundantly in various parts of India, but the industry is dependent on foreign sources of soda ash. Attempts have been made to utilize rocks rich in alkalis as a partial substitute for soda ash. Results of attempts to utilize reh deposits as a substitute for soda ash in a glass batch are reported. In India, reh is found in the Pleistocene deposits of the Gangetic alluvium. It is a peculiar saline efflorescent product covering the surface of the earth and destroying, in a great measure, its agricultural fertility. Reh salts are a mixture of carbonate, sulfate, and chloride of sodium together with calcium and magnesium salts derived originally from the chemical disintegration of the detritus of the mountains, dissolved by the percolating waters, and carried to the surface by capillary action in the long dry weather. It varies in chemical composition in different areas. Batches containing reh in increasing quantities were air-dried at 110°C. for about 3 hr. The reh used analyzed as follows after drying: SiO_2 70.80%, R_2O_3 12.00% (Al_2O_3 + Fe_2O_3), RO 3.68% (CaO + MgO), and R_2O 12.80 (Na_2O + K_2O). The glasses were melted in 1-lb. pots in an oil-fired furnace at temperatures of 1350° to 1400°C. The following batch was ideal for the manufacture of glass bottles:

Glass composition (%)		Batch	
SiO_2	69.00	Sand	33.60
RO	6.0	Reh	50.00
R_2O	18.0	Lime	5.49
R_2O_3	6.0	Soda	19.82
B_2O_3	1.0	Borax	1.40

The iron content of reh gives a greenish color to the glass, and this is not undesirable for bottle glass. The authors conclude that reh can be used as a partial substitute for soda ash; this gives a saving of 25% in the cost of raw materials and a reduction of 33% in the soda-ash requirement. A.P.S.

Glass reinforcement for concrete. Anon. *Engineering*, **150** [3897] 225 (1940).—For economic purposes, attempts were made to substitute glass strips for the usual iron reinforcement bars in concrete. The glass reinforced concrete compared favorably with iron reinforced concrete for static loading but not for impact loading. The ordinary type of glass was used, the bars being $^5/_{16}$ in. thick and $2^1/_4$ in. wide. In impact tests, the glass strips tended to break. B.C.R.

Hardened safety glasses of Czechoslovakia. O. Přidal. *Sklářské Rozhledy*, **14** [7] 117–21 (1937); *Chem. Obzor*, **13**, Abstracts 135; *Chem. Abs.*, **33**, 826 (1939).—The single-layer hardened glass produced under the trade name Mirit or Thorax-Restex was equal to the best brands in quality.

Impact tests on glass tile. Anon. *Engineering*, **150** [3889] 66 (1940).—Single disks of toughened "Armourlight" glass could be pierced by a 0.45-in. bullet fired from a Colt revolver at a distance of 10 yards. In a double unit, however, the first lens was penetrated and diced but the second lens remained undamaged even when the bullet was fired from a distance of 5 yards. B.C.R.

Insulating block. Anon. *Power Plant Eng.*, **44** [9] 100 (1940).—A new insulating material (B-H Mono-Block) suitable for use up to 1600°F. is described. It is composed of rock wool felted and bonded together. B.C.R.

Internal binding energy and constitution of glass: I, Viscosity of glass at temperatures near the transformation point. Taro Moriya. *Jour. Soc. Chem. Ind. Japan*, **42** [10] 746–48 (1939); Supp. Binding, pp. 357–58B.—M. studied the constitution of glasses by investigating their internal molar binding energy by first measuring the viscosity. The apparatus used to measure the viscosity of glass near the transformation temperature is described. This apparatus was also used to measure the coefficient of thermal expansion of glass. A lead glass was studied. The relation between log η and $1/T$ existing in the temperature range studied may be represented closely by two straight lines; these break at a certain temperature which M. contends is a transformation temperature. This point is obtained more exactly by this method than by thermal expansion measurement. The coefficient of viscosity of the sample at this point has a value of approximately 2.4×10^{14} c.g.s. **II, Viscosity and internal binding energy of soda-silica glasses.** *Ibid.*, pp. 748–50; Supp. Binding, pp. 357–58B.—The value for the internal binding energy of glass can be derived from the slope of the straight line of the log $\eta - 1/T$ curve which represents the magnitude of the latent heat of the liquid. For several soda-lime glasses, the values were calculated above and below the

transition point. The binding energy decreases with increase of SiO_2 above that temperature, while it increases below the transformation point. **III, Viscosity and internal binding energy of Na_2O-B_2O_3-SiO_2 glasses.** *Ibid.*, [11] 774–75; Supp. Binding, p. 367B.—The coefficient of viscosity, the transformation temperature, and the internal binding energy were determined for glasses composed of $1.0Na_2O \cdot xB_2O_3 \cdot 5SiO_2$ ($x = 0.5$, 1.0, or 1.5). These glasses have a higher internal binding energy above the transition point than below it. The increase of B_2O_3 increases the values both above and below this temperature. **IV, Internal binding energy of glass and glassy state.** *Ibid.*, pp. 775–77; Supp. Binding, p. 367B.—Using the experimental data in Parts I and II and those obtained by other authors such as H. R. Lillie (*Jour. Amer. Ceram. Soc.*, **14** [7] 502–11 (1931)) or Heidtkamp and Endell (*Ceram. Abs.*, **15** [9] 272 (1936)), the probable internal binding energy-temperature curves were examined for a series of soda-lime glasses over a wide range of temperature. The "glassy state" was also considered. M. concludes that, at high temperature, the compound Na_2O-SiO_2 may exist in the soda-silica glass. M.T.

Isochromates in glass with internal tension. Jar. Polívka. *Tchéco Verre*, No. 2, p. 27 (1937); *Chem. Obzor*, **13**, Abstracts 135; *Chem. Abs.*, **33**, 825 (1939). —The existence of isochromates is contrary to the fundamental Brewster-Wertheim law. See *Ceram. Abs.*, **15** [11] 331 (1936).

Lenses for high myopia. E. J. Crundall. *Optician*, **99** [2599] 153–56 (1940).—The disadvantages of the flint glass originally used include its weight, lack of resistance to scratching, and yellow color. Dense barium crown glass is recommended. M.B.H.

Lime arsenate and sodium antimonate as refining agents for glass. L. Springer. *Glashütte*, **70** [34] 443–44 (1940).—As far as can be determined by the laboratory tests which can be applied to mass production, Ca arsenic and Na antimony are good refining and decolorizing agents and can be used instead of arsenic and antimony oxide in the glass melt. They must be used in somewhat larger amounts, however, to replace not only the arsenic and antimony oxide but also saltpeter. Because of the lime content of Ca arsenic, S. recommends the omission of some of the limestone in the batch. More soda should be used instead of saltpeter, e.g., instead of 3 Na saltpeter and 0.6 arsenic, 3 Ca arsenic, less than 2 limestone, and 2 soda should be used. The chemicals for colorless glass, especially crystal, must contain no coloring ingredients such as cobalt. M.V.C.

Making tested mold lubricants. F. Mergler. *Glashütte*, **70** [24] 301 (1940).—The lubricants for cast-iron molds used in the mass production of thin-walled glass objects should be applied daily, after the old dried coatings have been carefully removed. They should be evenly but thinly applied (about 2 mm. thick) and should contain no coarse-grained powdered charcoal or like substances which cause imperfections in the glass. A good lubricant consists of 1 liter of varnish and $^1/_3$ liter of linseed oil boiled with some colophony; 5 kgm. of finely sifted minium are stirred in, and 40 cc. of turpentine are added. This mixture is applied thinly to the iron forms which have been thoroughly cleaned. The mold is then filled $^1/_4$ full with powdered charcoal and is shaken well; powder which does not adhere is emptied out. The mold is left to dry several hours or overnight. Before use, about ten glass objects should be blown in the mold to smooth the surface and to remove coarse grains of charcoal or particles of dust. The thickness of the coat is determined by measuring the diameter of the blown glass objects. A more durable and better adhering lubricating coat for glasses which must have accurate dimensions is composed of 1 liter of varnish, 1 liter of linseed oil, 300 gm. of colophony, and 250 gm. of "chestnut meal," all boiled together. This lacquer is also powdered with charcoal dust. Forms used for the manufacture of opal glass must be recoated after 1 or 2 hr. with varnish and fine charcoal, usually 1 part finer charcoal, 1 part coarser charcoal, and 1 part graphite. In this case the grain size of the coal dust and graphite is very important. A table giving the percentages of coarse and fine coal and graphite and the grain size is included as an aid in judging the most satisfactory mixture. M.V.C.

Manufacture of copper-colored glass. F. Mergler. *Glashütte*, **70** [25] 315–16 (1940).—The problem of producing small glass objects of the color of metallic copper (not copper ruby) is not simple, especially in the case of very small objects such as glass pinheads. In 1884, C. v. Marx and J. Wallensteiner (*Gewerbeblatt aus Würtemberg*, p. 22 (1885)) worked out the following composition for copper-colored glass pinheads: SiO_2 45.29, Al_2O_3 1.38, Fe_2O_3 0.12, Bi_2O_3 0.08, MgO 0.95, CaO 3.38, PbO 37.04, MnO 3.09, Na_2O 6.01, K_2O 1.18, and Cu 2.20%. The batch is made up as follows: 100 quartz sand, 12 potassium feldspar, 12 dolomite, 8 marble powder, 94 minium, 25 soda, 10 pyrolusite, 6.5 cuprous oxide, 6 tartar, and 0.2 bismuth trioxide (or 0.55 bismuth nitrate). The batch is thoroughly mixed and is melted in a 20 kgm. clay crucible. When cold, the glass obtained is almost black but is green around the edges. After it is reheated in a blast lamp, it can be shaped into small objects which will turn a copper color when held in a reducing flame for a few seconds. This glass must be worked with a blast lamp or the copper color will not appear. M.V.C.

Manufacture of glass wool and its importance for the German textile industries. Max Gerardes. *Kunstseide*, **22**, 77–78 (1940); abstracted in *Chem. Zentr.*, **1940, I**, 3158.—G. reviews different processes of manufacturing glass wool. The process most important for industry is the "steam process" in which the fused liquid glass is centrifuged through highly heated resistant metal nozzles into filaments. This is done by water steam under high pressure. The suitability of glass fiber for textile purposes is discussed. The smoothness of the fibers causes difficulty in working. M.V.C.

Manufacture of structural glass. Anon. *Glass Ind.*, **20** [6] 215–20 (1939).—The Pittsburgh Plate Glass Company's Works No. 6 at Ford City, Pa., produces opaque, colored plate glass (Carrara) and heavy polished plate (Herculite) which is mostly for tempering. Plant operations characterized by a wide range of batches and products are described and illustrated. 19 photographs. A.P.

Melting experiments with composite glasses. A. Prade. *Electrowärme*, **10** [9] 159–60 (1940).—Composite glass is a mixture of coarse sand (gravel) and red oxide of lead in the ratio of 20:15 to 20:35; it is melted in pots of about 70 kgm., and there are usually 8 pots to a furnace. Using coal as fuel, the maximum temperature of 1400°C. is usually reached in about 12 hr.; the furnace is kept at this temperature for 12 hr. and is then bricked up and left to cool. At a certain temperature the pots are broken, and the glass is ready for further operation. Experiments are described with an electrically heated furnace in which metallic heating elements were used. The maximum temperature required was only 1260° to 1300°C. In the coal-fired furnace the melt could not be observed directly; with the electric furnace, samples can be taken at any phase of the melting process, and gas development, composition, disintegration of crystal water, and temperature can be measured continually. The metallic heating elements were not injured or corroded by the gases developed during melting. The colors of glasses made in this furnace are purer; for topaz colors, preburned illuminating gas made a good protective atmosphere; it was used after boiling, during purification firing and cooling down to 500°C. The electric furnace is economical; 5 kw.-hr. were required per 1 kgm. of glass in a coal furnace changed over to electric firing, and less time is required in a specially designed furnace. Waste and rejects are reduced, as glass of better quality is produced. Defective glasses from the coal furnace could be regenerated in an electric furnace. M.H.

Melting of glass in tanks. Anon. Translated in *Glass Ind.*, **20** [8] 297–98 (1939); see "Working . . . ," *Ceram. Abs.*, **18** [3] 73 (1939). A.P.

New ovenware production at McKee Glass. Anon. *Glass Ind.*, **20** [7] 251–55 (1939).—Glasbake ovenware is being produced with a new continuous tank having inter-

esting features of design and control and a new muffle-type lehr. 11 photographs. A.P.

Physics in the glass industry. W. E. S. TURNER. *Nature*, **145** [3673] 446–48 (1940).—T. briefly recounts the ways in which physics has assisted in transforming glassmaking into an enterprising and efficient industry. Subjects at present insufficiently explored include thermal properties at high temperatures, such as specific heat, thermal conductivity, and emissivity. J.L.G.

Precise product control at Owens-Corning plant. ANON. *Glass Ind.*, **20** [8] 289–95 (1939).—Modern batch preparation and handling equipment at the Newark, Ohio, plant of the Owens-Corning Fiberglas Corporation insures uniform quality and maintains the essential properties of unusual glass products. 14 photographs. A.P.

Producing frothed glass. I. I. KITAĬGORODSKIĬ AND L. M. BUTT. *Prom. Stroitel. Materialov*, 2 [3] 21–31 (1940).—A method based on the sintering together of pulverized glass mixed with a gas-generating agent has been worked out. Na_2CO_3, K_2CO_3, NH_4SO_4, kaolin, and different kinds of coal were investigated. Anthracite coal was the most expedient for this purpose, giving glass with a good structure and a bright yellowish green color. Glass of good structure can be obtained with anthracite coal at various temperatures, but the higher the temperature, the quicker is the process. The best temperature is 900°C. The size of the pores can be regulated by varying the time of heat-treatment and the amount of the gas-generating agent. The most favorable conditions are 20 min. and 1%, respectively. The fineness of grind of both glass and coal should be 4900 mesh per $cm.^2$. The conditions for obtaining large samples of the glass were investigated. Its properties include low volume weight, low thermal conductivity, high mechanical strength, impermeability to moisture, high sound-insulating capacity, and a mechanical treatability. See "Penoglass," *Ceram. Abs.*, **19** [9] 212 (1940). P.B. & E.S.

Progress in glass in 1939. H. S. WHERRETT. *Ceram. Age*, **35** [1] 23, 25 (1940).—Technical advances are briefly reviewed. F.G.H.

Reaction between metals and molten glass. A. E. BADGER AND B. BARD. *Jour. Amer. Ceram. Soc.*, **23** [11] 326–27 (1940). **Editorial discussion.** *Ibid.*, pp. 327–28. **Reply.** A. E. BADGER. *Ibid.*, p. 328.

Relation of density and refractive index to composition of glass: I and II. KUAN-HAN SUN, HURD W. SAFFORD, AND ALEXANDER SILVERMAN. *Jour. Amer. Ceram. Soc.*, **23** [11] 315–26; [12] 343–54 (1940).—25 tables, 117 references.

Report on activities of A.S.T.M. Committee C-14 on Glass and Glass Products. LOUIS NAVIAS, *Secretary*. *Bull. Amer. Ceram. Soc.*, **19** [10] 411–12 (1940).

Simplified procedure for cleaning glass with chromic sulfuric acid. CASPAR TROPP AND FRITZ GEIGER. *Biochem. Z.*, **304**, 81–83 (1940); *Chem. Abs.*, **34**, 3541 (1940).

Structure and properties of glasses containing boron. MAURICE L. HUGGINS. *Jour. Amer. Chem. Soc.*, **62** [8] 2248 (1940).—The effect of boron on the volume, refraction, and dispersion of silicate glasses is briefly discussed. F.G.H.

Eugene C. Sullivan. ANON. *Bull. Amer. Ceram. Soc.*, **19** [10] 378–79 (1940).

Surface phenomena of glass melts. Preliminary report. D. S. LEV. *Mineral. Syr'e*, **1938**, No. 1, pp. 59–61; *Khim. Referat. Zhur.*, **1938**, No. 6, p. 15; *Chem. Abs.*, **34**, 6029 (1940).—The addition to the glass mixture of small amounts of tungstic acid or of Li_2CO_3 led to the formation on the glass of a stable surface film which facilitated the formation of a stable foam. These additions are "mineralizers," i.e., they favor the crystallization of glass. The existence in glass of a stable surface film possessing an anomalous η is reviewed.

Tableware glasses melted in tanks. ANON. Translated in *Glass Ind.*, **20** [6] 229–30 (1939); see "Hollow . . . ," *Ceram. Abs.*, **18** [4] 97 (1939). A.P.

Technological properties of glass silk and glass wool. PAUL AUGUST KOCH AND GÜNTHER SATLOW. *Klepzigo Text.-Z.*, **43**, 211–15 (1940); abstracted in *Chem. Zentr.*, **1940, I**, 3158.—Technical tests were made on glass fiber, glass thread, and glass bands, especial attention being given to the glass thread made by Gerresheimer Glashüttenwerke (Gerrix glass silk, Gerrix glass wool, and Gerrix spun glass wool bands). The fineness of the fibers, the microscopic picture, specific gravity, uniformity, and strength of glass silk, glass wool thread, and glass bands were determined. M.V.C.

Temperature characteristics of dielectric losses at high frequencies. TAKEO AKAHIRA, MASAO KAMAZAWA, AND YUZI TUMITA. *Bull. Inst. Phys. Chem. Research* [Tokyo], **18**, 517–28 (1939).—The change in the dielectric loss of insulating materials at high frequencies when the temperature changes from room temperature to about 200°C. was studied. The method and apparatus are discussed. Experiments were made on soda glass, borosilicate glass, steatite bodies, titanium bodies, micas, and Bakelite. When the temperature rises, the dielectric loss increases considerably; the moisture content is important. Y.K.

Thermolux glass—insulating, translucid, light-diffusing. M. DE TAILLY. Translated in *Glass Ind.*, **20** [7] 265–68 (1939); see *Ceram. Abs.*, **18** [5] 126 (1939). A.P.

Trends in decorative glass. M. A. ROSS. Read before Western Division, National Glass Distributors Assn., Chicago, Sept. 10, 1940; abstracted in *Amer. Glass Rev.*, **59** [50] 19–20 (1940). A.P.

Trends in plate glass sales. D. C. BURNHAM. Read before Western Division, National Glass Distributors Assn., Chicago, Sept. 10, 1940; abstracted in *Amer. Glass Rev.*, **59** [50] 17 (1940). A.P.

Two-phase glasses: IV, Copper-ruby glass. I. SAWAI, A. MITA, AND M. MINE. *Jour. Soc. Chem. Ind. Japan*, **42** [11] 822–23 (1939); Supp. Binding, pp. 388–89B.—The constitution of glasses in the two-phase system, their colorizing actions, and their mechanisms were studied. Copper-ruby glass was chosen as a representative. For the ground glass, soda-lime glass containing 73 SiO_2, 9 CaO, and 18% Na_2O was used; to this 0.3 to 1.8% Cu_2O and four times that amount of SnO were added to make various kinds of glasses containing copper constituents. These samples were placed in an electric furnace with uniform heat distribution and were heated for different periods of time. The colorizing action was investigated by means of the heating time, heat distribution, and copper content. The changes in color concentrations were measured by means of a microphotometer, and the coefficients of transparency were obtained. From the curves of color concentrations, each temperature at which the colorization begins and ends and the first and second maximum points where color concentrations occur were determined. Effects of heating times were also studied. There is a certain relationship between the temperatures of beginning of deformation (X), of maximum surface tension (Y), and of beginning of fluidization (Z). For Parts I and II see *Ceram. Abs.*, **17** [5] 181 (1938). M.T.

Ultraviolet lamps. ANON. *Manchester Guardian Commercial*, **36** [926] 251 (1938).—A new lamp developed by the British Thomson-Houston Co. is described. F.J.H.

Use of a viscosimeter in the tank furnace. K. G. KUMANIN. *Stekolnaya Prom.*, **15** [1] 19–21 (1939).—K. discusses the advantage of measuring the viscosity of the glass mass instead of determining it by temperature measurements. M.V.C.

Uses for corrugated wire glass. MISSISSIPPI GLASS CO. *Nat. Glass Budget*, **55** [21] 17 (1939).—Three types of wire glass are described: (1) heavy wire glass with deep 100° angle corrugations, $2^1/_2$ in. center to center, and an over-all thickness of slightly over 1 in.; (2) wire glass made according to the same specifications, used only in Coolite heat-absorbing glass required in large roof areas where an abundance of soft cool light is needed; and (3) shallow type corrugated wire glass made only in standard flint designed for use in buildings where the maximum amount of daylight is needed. Aside from its use in roofs and side walls of industrial construction it has been suggested for use in porches, workshops, formal gardens, farm buildings, etc. H.E.S.

White striation and crystal formation in glass during the manufacturing processes. FRITZ JOCHMANN. *Glashütte*, **70** [32] 395-97 (1940).—Different kinds of white striation may be formed during manufacture. In one case, it is produced by flue gases resulting from faulty furnace conditions and is not caused by improper work methods. Striation produced by crystallization phenomena depends on the high silicic acid content in the glass and results from differences in temperature in the furnace and the method of working the glass. It occurs in pressed glass. Photomicrographs illustrate these phenomena. In the manufacture of glass tubes, such factors as composition of the glass, temperature, and working processes also contribute to crystallization. Not only the chemical composition but also the thermal processes have a certain effect. M.V.C.

PATENTS

Apparatus for:

Banding articles. H. R. SCHUTZ (Libbey Glass Co.). U. S. 2,215,981, Sept. 24, 1940 (Feb. 2, 1937).

Manufacture of mineral wool. D. C. DRILL (American Rock Wool Corp.). U. S. 2,219,384, Oct. 29, 1940 (Sept. 30, 1937).

Producing hollow glass articles. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,215,984, Sept. 24, 1940 (Oct. 13, 1938).

Tempering flat glass. PILKINGTON BROS., LTD., AND G. W. T. BIRD. Brit. 526,052, Sept. 25, 1940 (March 7, 1939).

Tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 525,948, Sept. 18, 1940 (March 3, 1938).

Apparatus and method for circulating molten glass in a feeding container. K. E. PEILER (Hartford-Empire Co.). U. S. 2,217,182, Oct. 8, 1940 (Nov. 4, 1937).

Applying mirror surfaces to the interior of lamp bulbs. M. E. MACKSOUD (Birdseye Electric Corp.). U. S. 2,217,228, Oct. 8, 1940 (Aug. 18, 1937).

Bending glass sheets. O. H. PADDOCK (Libbey-Owens-Ford Glass Co.). U. S. 2,218,654, Oct. 22, 1940 (Aug. 28, 1937).

Burning off glassware. C. W. SCHREIBER (Libbey Glass Co.). U. S. 2,215,980, Sept. 24, 1940 (April 7, 1939).

Composite glass-metal article. V. H. FRAENCKEL (Hygrade Sylvania Corp.). U. S. 2,219,574, Oct. 29, 1940 (June 1, 1936; March 29, 1937).

Corner-grinding machine. P. J. KIRKMAN (Libbey-Owens-Ford Glass Co.). U. S. 2,218,646, Oct. 22, 1940 (June 25, 1938). U. S. 2,218,647, Oct. 22, 1940 (May 14, 1940).—A machine for grinding the corners of sheets or plates of glass.

Devices having sealed vitreous envelopes through which pass electric conductors. GENERAL ELECTRIC CO., LTD., AND R. L. BREADNER. Brit. 525,380, Sept. 11, 1940 (Feb. 20, 1939).

Double glazed window construction. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,219,699, Oct. 29, 1940 (June 8, 1939).

Drawing sheet glass from the molten mass. DEUTSCHE TAFELGLAS AKT.-GES. (Detag). Brit. 525,898, Sept. 18, 1940 (April 2, 1938).

Edge-grinding machine. H. O. KRANICH (Libbey-Owens-Ford Glass Co.). U. S. 2,218,648, Oct. 22, 1940 (June 22, 1938).

Electric furnace. GAMES SLAYTER, F. W. ATKINSON, AND ED FLETCHER (Owens-Illinois Glass Co.). U. S. 2,215,982, Sept. 24, 1940 (Jan. 20, 1939).—Apparatus for melting and fining glass.

Electric glass furnace. JOHN H. THOMAS (Owens-Illinois Glass Co.). Can. 391,830, Oct. 8, 1940 (April 29, 1938). G.M.H.

Electric melting furnaces intended particularly for the manufacture of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 526,799, Oct. 9, 1940 (Sept. 17, 1938).

Forming molten glass into thin streams from which threads or fibers are drawn. VETROCOKE. Brit. 526,682, Oct. 9, 1940 (April 14, 1938).

Glass machine operating cam. J. A. LEWIS (Sneath Glass Co.). U. S. 2,216,318, Oct. 1, 1940 (Nov. 5, 1938; Dec. 14, 1939).

Glass-metal seal. HOWARD SCOTT (Westinghouse Electric & Mfg. Co.). U. S. 2,217,422, Oct. 8, 1940 (April 24, 1936); see *Ceram. Abs.*, **16** [2] 62 (1937).—A vacuum-tight seal between a vitreous material having an expansivity of 6.5 to 10 × 10^{-6} cm. per cm. per °C. and an alloy comprising 43 to 45% nickel, 10 to 15% cobalt, from a trace to less than 1% manganese, and the remainder iron.

Glass-to-metal seal. HOWARD SCOTT (Westinghouse Electric & Mfg. Co.). U. S. 2,217,423, Oct. 8, 1940 (April 30, 1936; renewed July 17, 1940). H. L. THORSON (General Electric Co.). U. S. 2,220,742, Nov. 5, 1940 (May 28, 1938).

Glass-to-metal seal. ALBERT W. HULL AND EMMETT E. BURGER (Canadian General Electric Co., Ltd.). Can. 391,613, Oct. 1, 1940 (April 27, 1937). G.M.H.

Glass for motor vehicle lights. OTTAVIO BORSARELLI. U. S. 2,220,639, Nov. 5, 1940 (Feb. 11, 1938).

Glass-polishing apparatus. F. B. WALDRON AND J. H. GRIFFIN (Pilkington Bros., Ltd.). Can. 390,848, Aug. 20, 1940 (March 22, 1939). G.M.H.

Glass-pressing machine. F. L. O. WADSWORTH (Ball Bros. Co.). U. S. 2,217,425, Oct. 8, 1940 (March 4, 1935; May 29, 1937).

Glass strip grinding and polishing apparatus. F. B. WALDRON AND J. H. GRIFFIN (Pilkington Bros., Ltd.). Can. 391,512, Sept. 24, 1940 (March 13, 1939). G.M.H.

Glassware manufacture. T. F. PEARSON AND RALPH R. PREST (Crown Cork & Seal Co., Inc.). Can. 391,290, Sept. 10, 1940 (July 2, 1937). G.M.H.

Glass wool apparatus. E. H. WELLECH (Owens-Corning Fiberglas Corp.). U. S. 2,220,433, Nov. 5, 1940 (Dec. 30, 1937).

Laminated glass. F. L. BISHOP, FOX C. MANOR, AND CHARLES S. SHOEMAKER (American Window Glass Co.). Can. 391,992, Oct. 15, 1940 (April 6, 1934). G.M.H.

Laminated glass manufacture. ADOLF KÄMPFER. Can. 390,445, July 30, 1940 (May 4, 1936). G.M.H.

Laminated product. E. W. FAWCETT, R. O. GIBSON, AND M. W. PERRIN (Imperial Chemical Industries, Ltd.). U. S. 2,219,684, Oct. 29, 1940 (March 2, 1939).

Lehr charger. W. S. MAYERS (Frangeo Co.). U. S. 2,220,454, Nov. 5, 1940 (Feb. 14, 1938).

Low-reflectance glass. K. B. BLODGETT (General Electric Co.). U. S. 2,220,862, Nov. 5, 1940 (April 28, 1939).—The method of improving the optical properties of a body of soda-lime glass comprises fusing to the body a surface layer of a second glass containing a metallic constituent which imparts a high refractive power to the second glass and then superficially etching the second glass to remove the metallic constituent to a depth corresponding approximately to a quarter wave length of some component of visible light.

Luminescent glass. WALTER HÄNLEIN (General Electric Co.). U. S. 2,219,895, Oct. 29, 1940 (April 19, 1939).—A translucent, luminescent glass in which the components rendering the glass translucent consist of luminescent materials segregated out in the crystalline form, the glass being substantially free from alkalis.

Luminous brick and construction comprising them. E. B. BAKER (General Electric Co.). U. S. 2,216,220, Oct. 1, 1940 (Aug. 25, 1937).—A structural wall composed of bricklike hollow sealed blocks of light-transmitting material, an ionizable gaseous atmosphere within the blocks adapted to be rendered luminous upon passage of an electric current therethrough, the blocks each serving as the enclosure for the gaseous atmosphere therein, and current conductors for supplying electrical energy to the blocks, the conductors being arranged within the wall whereby both sides of the wall present a substantially smooth unobstructed surface.

Machine for polishing or grinding lenses, etc. DOUGLAS TAYLOR. U. S. 2,219,641, Oct. 29, 1940 (Oct. 24, 1939). Brit. 526,919, Oct. 9, 1940 (March 29, 1939).

Making composite glass-metal articles. V. H. FRAENCKEL (Hygrade Sylvania Corp.). U. S. 2,219,573, Oct. 29, 1940 (June 1, 1936).

Making rock-wool articles and apparatus therefor. W. E. CARSON. U. S. 2,217,538, Oct. 8, 1940 (Oct. 23, 1937).

Manufacture of bottles or other hollow articles of glassware. T. F. PEARSON AND R. R. PREST (Crown Cork & Seal Co., Inc.). U. S. 2,217,811, Oct. 15, 1940 (June 29, 1937).

Manufacture of glass. P. E. HARTH. U. S. 2,218,334, Oct. 15, 1940 (Aug. 28, 1937).—In the art of making glass, the process comprises adding to the glass batch a fluxing material containing fluorspar-barite ore.

Manufacture of sheets and plates of reinforced glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 525,442, Sept. 11, 1940 (Feb. 26, 1938).

Manufacture of siliceous bodies. G. J. BAIR AND R. A. MILLER (N. S. Garbisch). U. S. 2,220,750, Nov. 5, 1940 (March 29, 1938).—A process of preparing coherent masses of glass batch material containing intimately and uniformly associated mixtures of silica and glass particles bonded together by the alkali and alkali earth metal fluxes of the batch comprises filtering an aqueous slurry of waste sand obtained from the grinding and polishing operations of glass plates to remove the major portion of the water and obtain a damp mass, the waste sand comprising a mixture of about 10 to 25% of glass, the rest being essentially silica, the glass and silica in the mixture being of a particle size such that most of it will pass a screen of about 325 mesh, mixing the damp mass with alkali metal and alkali earth metal fluxes, at least some of which fluxes are at least partially anhydrous and are soluble in water, to form a glass batch whereby the soluble fluxes are at least partially dissolved in the residual water of the damp mass, and forming the mixture into bodies of a suitable size for incorporation into a glass batch with the fluxes and water constituting the bonding agents.

Method and apparatus for facilitating inspection of glass articles. C. A. EVERETT (Owens-Illinois Glass Co.). U. S. 2,219,572, Oct. 29, 1940 (Oct. 22, 1938).

Method and apparatus for severing glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,219,698, Oct. 29, 1940 (Nov. 4, 1937).

Molding hollow shapes. S. T. MORELAND (Owens-Illinois Glass Co.). U. S. 2,219,576, Oct. 29, 1940 (Feb. 16, 1938).

Molten glass severing mechanism. W. T. HONISS (Hartford-Empire Co.). U. S. 2,218,970, Oct. 22, 1940 (April 25, 1938).

Operating mineral-wool furnace. W. R. SEIGLE, H. J. O'BRIEN, AND G. S. SMITH (Johns-Manville Corp.). U. S. 2,215,887, Sept. 24, 1940 (May 4, 1937; renewed March 1, 1940).

Paddle for operating in the forehearths of glass furnaces. F. W. ARMYTAGE. U. S. 2,220,635, Nov. 5, 1940 (Nov. 26 1937).

Process for the manufacture of hollow articles in glass or other material capable of being drawn in the plastic state. SOC. DES PRODUITS CÉRAMIQUES DE SARS-POTERIES. Brit. 526,058, Sept. 25, 1940 (March 18, 1938).

Production of glass vessels. J. DICHTER. Brit. 526,-613, Oct. 2, 1940 (March 23, 1938).

Protective glass. FRANZ WEIDERT AND HANS LÖFFLER (Degea A.-G. (Auergesellschaft)). U. S. 2,219,122, Oct. 22, 1940 (May 21, 1937).—A protective glass containing about 5% to 50% of neodymium oxide and an addition of vanadium oxide.

Reduction of surface reflection. K. B. BLODGETT (General Electric Co.). U. S. 2,220,861, Nov. 5, 1940 (June 16, 1938).

Refractory glass. MARCELLO PIRANI (General Electric Co.). U. S. 2,219,332, Oct. 29, 1940 (Oct. 14, 1938).—A partly or wholly vitreous material having a melting point not below 1550°C. and a thermal expansion coefficient substantially greater than 0.55×10^{-6} per °C., containing at least 75% of silica, at least 1% of (beryllia + ceria), at least 2% of (thoria + ceria), and not more than 7% of other oxides.

Refractory material and process of producing. R. W. RICKER (Libbey-Owens-Ford Glass Co.). U. S. 2,218,623, Oct. 22, 1940 (July 19, 1937).—A molded refractory article made from a batch comprising the following ingredients in the approximate proportions set forth: waste grinding material including finely ground sand and finely divided glass particles 100 parts by weight, hydrated lime 20 parts, water 24 parts, and wood rosin 0.5 part.

Sealing metal to quartz or vitreous material. BRITISH THOMSON-HOUSTON CO., LTD., L. J. DAVIES, H. CHENEY, H. K. BOURNE, AND E. J. G. BEESON. Brit. 525,965, Sept. 18, 1940 (March 1, 1939).

Splinterless glass. WERNER STARCK AND WERNER HEUER (General Aniline & Film Corp.). U. S. 2,219,433, Oct. 29, 1940 (Dec. 9, 1935).

System for obtaining thread by drawing, in particular glass threads with long fibers. ALDO CERETTI AND PIERO MODIGLIANI (Owens-Corning Fiberglas Corp.). U. S. 2,219,066, Oct. 22, 1940 (March 22, 1938).

Telescope eyepiece. ALBERT KÖNIG (Carl Zeiss). U. S. 2,217,281, Oct. 8, 1940 (Jan. 18, 1939).

Tempering articles and sheets of glass or metal. N. ROMANIN (née Drufuca). Brit. 525,732, Sept. 18, 1940 (Aug. 31, 1938).

Vitreous material. MITSUO HIROSE AND HIROSHI KAMOGAWA (General Electric Co.). U. S. 2,220,765, Nov. 5, 1940 (Feb. 7, 1938).—A capacitor dielectric element comprises a glass having a dielectric constant of about 20 and containing about 20 to 25 mol % titanium oxide, about 36 to 41 mol % lead oxide, and about 33 to 38 mol % silica.

Structural Clay Products

Artificial pozzuolana and sand-lime brick from Fijian raw materials. ANON. *Bull. Imperial Inst.*, **37** [3] 434–40 (1939).—An investigation was carried out to determine the suitability for building materials of coral, quartz sand, and red clay from Fiji. Chemical analyses and physical data are given. Satisfactory results were obtained in tests using the calcined red clay (at 700°C.) in place of trass with pure hydrated lime and standard sand; these brick exceed the specifications for commercial trass. A satisfactory sand-lime brick was made from 90% Rewa sand (a finely divided, light brown sand consisting chiefly of corroded quartz and well-rounded limonitic grains) and 10% hydrated lime (prepared from coral) formed under a pressure of 5000 lb. per sq. in. and subjected to steam at 130 lb. pressure. A.P.S.

Better construction, lower cost should encourage more building. MYRON W. ADAMS. *Ind. Standardization*, **10** [12] 298–301 (1939).—To coordinate the dimensions of building materials and equipment in the interests of efficiency and economy, a standardization project according to the procedure of the American Standards Assn. has been started. See also "Progress . . . ," this issue, p. 17. A.G.S.

Cavity brick wall. ANON. *Eng. News-Record*, **125** [11] 76 (1940).—Although hollow wall construction is standard practice in England, its use here is still in the experimental stage. It serves as insulation and prevents wall leakage. Metal ties are used in preference to header courses which may permit the passage of water from one wall to the other. B.C.R.

Hollow brick closed on all sides. G. PFISTER. *Tonind.-Ztg.*, **63** [56] 643–44 (1939).—Before the clay column extrudes from the mouthpiece it passes a plurality of inserted screws. When these rotate rapidly they produce cavities and propel the clay paste forward at the same time. When standing still the screws act as cores. Rapid change from rotation to standstill produces cavities and closes the air channels. This method makes it possible to use heavy, dry clays which would otherwise be unsuitable for making hollow brick. The all-closed hollow brick can be rapidly dried and fired. Bricklayers prefer them because of their lighter weight. Less mortar is required for these brick than for other hollow brick because mortar cannot enter the holes. Illustrated. F.E.S.

Progress Report of American Standards Association Sectional Committee A-62. FREDERICK HEATH, JR. *Bull. Amer. Ceram. Soc.*, **19** [10] 411 (1940); see *ibid.*, [5] 201-202; "Better . . .," this issue, p. 16.

Staffordshire blue brick and their uses: II. ANON. *Brick Builder*, No. 49, p. 35 (1938).—These brick are used in industrial buildings because of their resistance to the action of acids and their strength. Their high durability is due to the high firing temperatures which assure resistance to freezing and low absorption of moisture. **III.** *Ibid.*, No. 52, p. 36 (1938).—The advantages are given of the use of Staffordshire blue brick for paving and road-making with reference to experiments with them in Birmingham. The road paved with these brick was in excellent condition after 15 years of continuous use. M.B.H.

PATENTS

Brick. BUILDING INDUSTRIES SERVICES, LTD., AND L. W. BURRIDGE. Brit. 525,573, Sept. 11, 1940 (Feb. 23, 1939).

Building block construction. I. R. CLINE (Western Brick Co.). U. S. 2,216,875, Oct. 8, 1940 (April 6, 1939).—In a building block construction, a unitary block comprises spaced vertically extending wall portions and narrow spaced transverse webs between the wall portions, the webs extending vertically and having upper portions substantially pointed in cross section and located within the contour of the block.

Clay product. FLOYD B. HOBART (Battelle Memorial Institute). Can. 391,060, Sept. 3, 1940 (April 11, 1939).—The method of producing a lightweight ceramic product comprises producing a foamed ceramic liquid suspension and mixing therewith a slowly soluble sodium silicate powder that will slowly bring about gelation. G.M.H.

Composition for preventing efflorescence on clay brick. J. G. CONTE. U. S. 2,218,933, Oct. 22, 1940 (Sept. 9, 1939).—A composition for preventing efflorescence contains lubricating mineral oil, a mineral oil for thinning the lubricating mineral oil consisting of kerosene and crankcase oil, and 5% of acetic acid.

Tile or building brick and walls constructed therefrom. A. G. SHAW. Brit. 526,171, Sept. 25, 1940 (March 8, 1939).

Refractories

Action of alkalis on refractory materials: IV. F. H. CLEWS, A. CHADEYRON, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 38 (Sept., 1935); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [5] 124–35 (1940); see *Ceram. Abs.*, **15** [10] 301 (1936). **V.** F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 41 (Sept., 1936); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [5] 136–46 (1940); see *Ceram. Abs.*, **16** [5] 150 (1937). R.A.H.

Anomalies in the properties and behavior of silica brick. C. EDWARDS AND H. M. SPIERS. *Trans. Brit. Ceram. Soc.*, **39** [7] 210–35 (1940).—Routine testing of silica brick purchased from various manufacturers showed that brick from a particular source were characterized by a much lower afterexpansion than would have been expected from their true specific gravities and gave a dead ring when struck. The true specific gravity tended to increase when the brick were reheated to temperatures of 1450°C. or higher. The brick tended to be oversize and their porosity was higher than normal. Investigation showed that the weak structure was due to an excessive content of fines in the brick mixture and to a too rapid rate of temperature rise in the final stages of firing. The first factor leads to a dilution of the fluxes and a consequent loss of elasticity in the matrix while the second factor gives rise to the formation of strains and to the development of cracks due to the high speed at which conversion of the quartz occurs under such conditions. Examination of thin sections showed that the increase in true specific gravity with heat-treatment was accompanied by the conversion of tridymite into cristobalite. Results of tests on different brands of brick suggest that this increase in specific gravity is generally associated with brick containing less than 95% silica as a result of an abnormally high content of alumina or lime or both. If firing conditions are too drastic, the increase in specific gravity may occur in the kiln itself after a minimum value has been attained. In such cases, the true specific gravity alone does not enable a decision to be made as to whether the heat-treatment in the kiln has been adequate or excessive. R.A.H.

Cristobalite: I. HIDEO INUZUKA. *Jour. Geol. Soc. Japan*, **47** [563] 306–309 (1940).—I. investigated the formation and inversion temperature of cristobalite. It is recognized by many investigators that quartz and silica glass invert to cristobalite even at the temperature at which tridymite is stable, and, without a mineralizer, tridymite cannot be obtained even when they are heated for a long time at the temperature at which it is considered stable. Most of the earlier experiments were made to determine the modification of silica which inverts from quartz, silica glass, and amorphous silica. I. experimented, by the X-ray method, to identify the modification of free silica which formed at the stable temperature of tridymite. Quartz does not invert when heated at 1500°C. for 1 hr., but agate inverts to cristobalite completely when heated at 1350°C. for 1 hr. When 5 to 10% of agate are added to quartz, it inverts very easily when heated at 1350°C. for 1 hr. The X-ray pattern of amorphous silica heated at 1300° and 1400° for 1 hr. shows the existence of silicon and cristobalite. When talc is heated at 1100°C., it dissociates as follows: $H_2Mg_3(SiO_3)_4 \rightarrow H_2O + SiO_2 + 3MgSiO_3$; the X-ray pattern shows that silica is cristobalite. Y.K.

Cupola practice. DONALD J. REESE. *Foundry*, **68** [4] 30–32, 92–93 (1940).—Refractory requirements are briefly discussed. See *Ceram. Abs.*, **18** [10] 270 (1939). F.G.H.

Determining the suitability of raw materials for silica brick and refractory siliceous masses. I. S. KAĬNARSKIĬ. *Ogneupory*, **7** [9] 592–98 (1939).—Methods used in investigating siliceous raw materials for the manufacture of silica brick are discussed. M.V.C.

Effect of cupola practice on linings. C. K. DONOHO AND C. F. GREENE. *Trans. Amer. Foundrymen's Assn.*, **46**, 525–34 (1938).—Results are given of an investigation on the effect of blast pressure, nature of the charge, length of heating, and diameter of the cupola on consumption of refractories in the melting zone. The effects of blast pressure, silicon content, and length of heating are discussed. Results indicate that high blast pressures, low silicon irons, long heats, and small diameter cupolas cause excessive attack on the lining of the melting zone. H.E.S.

Effect of water content and mixing time on properties of air-setting refractory mortars containing sodium silicate. R. A. HEINDL AND W. L. PENDERGAST. *Bull. Amer. Ceram. Soc.*, **19** [11] 430–34 (1940).—5 figs., 7 references.

Electric furnace in the steel foundry. FREDERICK A. MELMOTH. *Trans. Electrochem. Soc.*, **77**, 73–80 (1940).—M. discusses the electric arc furnace used for the melting of metal, particularly for the production of liquid steel. The continuance and extension of the use of the electric

furnace process as it applies to foundries are dependent upon two main factors: (1) the limitations imposed by refractories and the possibility of improvement in this direction; and (2) the cost of electric power and furnace installation. Within reasonable limits, the full utilization of the heat made available by the electric arc depends upon the ability of the lining refractories to withstand it. F.G.H.

Experimental production and testing in service of semiacid steel-casting refractories from Borovichi-Lyubytino clays. V. M. Strelets, G. V. Grabovskiĭ, and S. P. Petrov. *Ogneupory*, **7** [8] 518–23 (1939).—Results are described of experiments on the manufacture and use of steel-casting refractory products made from a plastic clay sintering at low temperature, local semiacid clay, and low-fired grog. M.V.C.

Gas melting furnaces for foundry work. E. W. Williams. *Metal Ind.* [London], **56** [25] 533–36 (1940).—W. outlines an ideal melting furnace for a nonferrous foundry which will give maximum control of melting conditions. Nonferrous melting furnaces are divided into two classes, crucible and open-flame. Directions are given for building crucible furnaces of the stationary and tilting types and pear-shaped, open-flame furnaces. H.E.S.

Influence of titanium oxide on sintering of magnesite: I, Formation of magnesium titanate. Yasuo Tanaka. *Jour. Soc. Chem. Ind. Japan*, **42** [6] 387–90 (1939); Supp. Binding, pp. 202–204B.—One of the defects of magnesia refractories is that they spall easily. Magnesite from Southern Manchuria contains too little Fe_2O_3 to sinter well. The addition of Fe_2O_3 or Al_2O_3 to magnesite forms a spinel that helps sintering, and the prepared brick will resist spalling. T. describes studies on the preparation of spinel formed of TiO_2 and MgO and on its ability to sinter magnesite. Samples containing Fe_2O_3 were also examined. The results were as follows: (1) Solid reaction between MgO and TiO_2 can take place easily, and a final product of $2MgO \cdot TiO_2$ is obtained at 1400° to 1500°C., passing the course of an intermediate product such as $MgO \cdot TiO_2$ at 1300°C. $2MgO \cdot TiO_2$ has a spinel structure and belongs to the isometric system. Its lattice constant is $a = 8.44$ a. u. (2) If Fe_2O_3 is coexistent in it, $2FeO \cdot TiO_2$ is formed and mixes completely with $2MgO \cdot TiO_2$ in solid solution. In this case, Fe_2O_3 first converts to Fe_3O_4 and then forms a solid solution with orthotitanate which gradually becomes $MgO \cdot FeO \cdot TiO_2$ as the temperature increases. (3) Materials formed in this manner sinter well. **II, Effect of addition of substances containing titanium oxide on sintering of Manchurian magnesite.** *Ibid.*, pp. 390–92; Supp. Binding, pp. 204–205B.—Experiments were made on the effect of additions of small quantities of substances containing TiO_2 to Manchurian magnesite. Magnesite does not sinter at 1400°C.; the addition of Fe_2O_3 does not influence sintering. The addition of rutile or ilmenite to magnesite has a marked effect. The addition of 2 to 3% of these substances to magnesite makes it sinter considerably at 1300° to 1400°C. **III, Tests for resistances to rapid thermal changes.** Yasuo Tanaka and Tomoatsu Takagi. *Ibid.*, [12] 874–77; Supp. Binding, 405–406B.—The authors describe the measurement of porosity and the spalling test after substances containing TiO_2 were added to clinkers of Manchurian magnesite. The results are illustrated at each calcining temperature from 1200° to 1600°C. Comparisons are made with ordinary magnesia brick without additions. With additions, porosity increases and the resistance to rapid thermal changes decreases. The mechanisms for calcining and the constitutions of the products were also studied. See "Solid . . . ," *Ceram. Abs.*, **18** [7] 195 (1939). M.T.

Large-scale tests of unfired forsterite brick in open hearths. V. S. Gulyaev, L. G. Ugrinovich, A. M. Ostroumov, and V. M. Avvakumov. *Metallurg*, **15** [4] 44–48 (1940).—Experimental data are given on the use of unfired forsterite brick from dunite as a partial substitute for magnesite in open hearths. Forsterite brick proved to be the most stable when neither cooling nor facing was used. The formation of a dense zone in the thicker brickwork proceeded to a depth of 200 to 250 mm. This zone was particularly stable against the destructive action of reagents in the furnace. If this zone reaches a sufficient thickness, unlike that which takes place on the rear wall, then the spalling is greatly reduced. This indicates that in inclined and thicker walls of open hearths the brick should last a great deal longer. This was confirmed by experimental tests. B.Z.K.

Magnesia refractories for rotary cement kilns. V. S. Gulyaev. *Prom. Stroitel. Materialov*, **1939**, No. 2–3, pp. 70–78.—G. describes investigations on magnesite, forsterite, spinel, and dolomite refractories. The possible use of these refractories in cement kilns is shown. P.B. & E.S.

Manufacture of refractory insulating brick. Felix Singer. *Brit. Clayworker*, **49** [579] 83–86 (1940).—Methods for forming pores in a refractory body are listed in two groups: (1) Pores formed by an addition of solids: (*a*) combustion, (*b*) sublimation, (*c*) porous grog; and (2) pores formed by gas bubbles: (*a*) gas developed in the mixture, (*b*) development of foam. S. discusses the formation of pores by combustion and sublimation, used singly or together. R.A.H.

Metal melting—effect on quality. H. W. Brownsdon. *Engineer*, **160** [4157] 277–78 (1935).—The effect of refractories on metal quality is briefly discussed. Illustrated. F.G.H.

Mineralizers of silica refractories. Seiji Kondo, Toshiyoshi Yamauchi, and Tetsuo Eto. *Jour. Soc. Chem. Ind. Japan*, **43** [3] 202–207 (1940); Supp. Binding, p. 91B.—S. Kondo and T. Yamauchi (*Ceram. Abs.*, **15** [4] 134 (1936); **18** [6] 156 (1939)) confirmed the theory that sodium compounds are the most effective mineralizers for the tridymitization of quartz. Most Na compounds soluble in water, however, cause efflorescence on green ware and are not distributed uniformly through the unfired refractories. Experiments were made on (1) the introduction of frits containing soda, Na compounds slightly soluble in water, and natural Na minerals; (2) the seeding action of tridymite and cristobalite; and (3) the effect of Li and K compounds as the mineralizers of pulverized rock crystal. The following conclusions were reached: (1) Na frits such as $Na_2O + CaF_2 + 3SiO_2$ and $Na_2O + MnO_2 + 3SiO_2$ and Na oxalate are very effective for tridymitization. (2) Na minerals examined, viz., albite ($NaAlSi_3O_8$), nephelite ($m NaAlSiO_4 \cdot n KAl(SiO_3)_2$), and sodalite ($Na_4(AlCl)Al_2(SiO_4)_3$) are ineffective. (3) An addition of a small amount of artificial tridymite (3%) promotes the formation of cristobalite, while a larger addition (6 to 9%) promotes the formation of tridymite. The seeding action of artificial cristobalite is slight. (4) Lithia mica ($KLi\{Al(OH,F)\}_2Al(SiO_3)_3$) is worthless as a mineralizer. M.T.

Mullite. W. Hugill. *Trans. Brit. Ceram. Soc.*, **39** [5] 121–23 (1940).—H. discusses the two distinct forms of mullite found in investigations dealing with the reaction between slags and firebrick. The refractive indices of the older or normal form are much higher than those of the more recently discovered form of mullite. R.A.H.

Plastic cupola patching. R. E. Wilkie. *Trans. Amer. Foundrymen's Assn.*, **47**, 89–96 (1939).—A stiff mixture of fire clay and sharp sand is used in place of the conventional brick or block, resulting in economies in both refractory and labor. The refractory cost for a period in which 66,000 tons of iron were melted was $12.72 per 100 tons of melt. H.E.S.

Practical application of monolithic linings in cupolas. Anon. *Foundry Trade Jour.*, **61** [1216] 385 (1939).—The outstanding advantage of monolithic linings in cupolas is the elimination of joints which were always a source of trouble when brick were used. The practical application of the monolithic lining, the method of ramming, drying, operating details, patching, and expected life are discussed. A discussion is included. H.E.S.

Rationalization in firebrick works. A. Möser. *Tonind.-Ztg.*, **63** [58] 666–68; [59] 677–79; [60] 688–90 (1939).—Rationalization in the refractory industry must deal mainly with two problems, viz., the transportation of large masses and the thermal economy of the drying and firing process. F.E.S.

Refractories. W. GILBERT. *Indian Ceramics*, **2** [1] 24–26 (1939).—The main classifications of refractories and the process of their manufacture are briefly outlined. Indian refractory products are of high quality. The industry, which has been developing since ancient times, has its roots in the old civilization of India. A.P.S.

Refractories used in the steel foundry. A. V. LEUN. *Trans. Amer. Foundrymen's Assn.*, **47** [4] 534–41 (1940); see *Ceram. Abs.*, **18** [9] 246 (1939). H.E.S.

Refractory life in electric arc melting of steel and alloys. J. H. CHIVERS. *Bull. Amer. Ceram. Soc.*, **19** [11] 442–43 (1940).

Refractory masses for furnaces used in the manufacture of sulfate cellulose. S. M. VISHNEVSKIĬ. *Bumashnaya Prom.*, **17** [8] 23–27 (1939); abstracted in *Chem. Zentr.*, **1940, I,** 3160.—Experiments on the replacement of steatite lining (with a maximum life of 2 to 3 months) which is used in furnaces for fusing soda in the manufacture of sulfate cellulose showed that Cr magnesite block had the highest refractoriness and resistance to alkalis. It can, therefore, be recommended for the lower part of Wagner furnaces. Dense grog blocks were also approved, but they are inferior to Cr magnesite block. Fired steatite block have better properties than unfired block, but they are inferior to the other two materials. Pure chromite or dunite block are sensitive to sudden changes in temperature; pure magnesite block were resistant to alkalis, but after exposure to alkalis at high temperature they became permeable to dampness. M.V.C.

Reverberatory furnace with coal fuel, 1612–1712. RHYS JENKINS. *Engineer*, **157** [4071] 81–82 (1934).—J. gives a historical review of the reverberatory furnace used for the smelting of copper and lead. Details of furnace construction are included. Illustrated. F.G.H.

Service of refractories in annealing furnaces of the electrode industry. I. I. KUZMENKO. *Ogneupory*, **7** [9] 599–603 (1939).—K. describes furnaces used for calcining carbon materials for the electrode industry. The conditions of operation and the destruction of the refractory linings of these furnaces are discussed. The preheating zone should be lined with grog possessing high thermal stability and mechanical resistance. In the zones of firing and annealing, the grog refractories should be coated with a highly refractory protective lining. M.V.C.

Status of the electric arc furnace in industry. W. E. MOORE. *Trans. Electrochem. Soc.*, **77,** 63–72 (1940).—In the ingot field the modern top-charge, rapid-type electric furnaces are in competition with the open-hearth furnace for producing ordinary carbon steels of commercial grades. In the production of tool steels, stainless steels, and other alloys, the electric furnace is distinctly superior. During the past 25 years, decided improvements have been made in the quality of carbon electrodes and in furnace lining materials. Carbon blocks are now available for use as refractories and linings for electric furnaces and have a useful place in smelting furnaces for ferroalloys, carbide, phosphate, etc. The manufacture of silica blocks has progressed with regard to accuracy of shape and freedom from spalling. High-alumina brick have been improved and are especially useful in furnaces that operate on an occasional heat basis. Mullite rammed mixtures are being used successfully in commercial practice on the smaller size furnaces. Fused mullite refractories promise to be used more extensively in arc furnaces. Radical changes have been made in electric arc furnace design. Details of the development of the modern top-charge furnace are discussed. The new "lift-swing aside" roofs are very smooth and rapid in operation. Data for a 12-ton furnace are included. F.G.H.

Suspended furnace walls. ANON. *Mech. World & Eng. Record*, **108** [2802] 193 (1940).—One of the advantages of furnace walls suspended in steel frames over the ordinary "solid" wall is the elimination of air leakage because cracks caused by expansion and contraction are avoided. Measurements of temperatures at the inner hot and the outer cool surfaces of a furnace wall during firing show that the difference amounts to 1125°F. The coefficients of expansion at the inner and outer walls were 0.525% and 0.135%, respectively. F.E.S.

Titrimetric determination of the water permeability of insulating materials. WERNER NAGEL AND ELISABETH BRANDENBURGER. *Wiss. Veröffent. Siemens-Werken*, **18** [2] 97–104 (1939); *Chem. Abs.*, **33,** 8329 (1939).—An apparatus is described in which the moisture passing through a film is carried by a current of dry air into an excess of naphthalenephosphonyl chloride ($C_{10}H_7POCl_2$) (I), with which the H_2O reacts and liberates HCl which is in turn absorbed in a known amount of $Ba(OH)_2$ solution, and the excess $Ba(OH)_2$ is titrated. Cinnamyl chloride may be used instead of I. The apparatus, with suitable modification, may be used for the permeability of either gaseous or liquid H_2O through the films. Values are given for the water permeabilities of styroflex, benzylcellulose, and train oil.

Use of cast alumina refractories in the glass industry. H. N. BAUMANN, JR., AND A. A. TURNER. *Jour. Amer. Ceram. Soc.*, **23** [11] 334–38 (1940).—10 photomicrographs.

Preparation of pure alumina from Manchurian clay: VII, Preparation of aluminum hydroxide by treatment of ammonium alum with ammonia under ordinary pressure. TSUYOSHI ARIMORI. *Jour. Soc. Chem. Ind. Japan*, **42** [10] 735–38 (1939); Supp. Binding, p. 355B.—Results are summarized as follows: (1) Aluminum hydroxide precipitated from the crystalline alum with ammonium hydroxide under ordinary pressure contains less SO_4'' than the precipitates obtained by the treatment of the same alum with ammoniacal solutions saturated with ammonium sulfate. (2) The aluminum hydroxide precipitated from dehydrated alum and that precipitated from crystalline alum with ammonium hydroxide are equally pure, and it is therefore unnecessary to dehydrate the alum before this treatment. (3) When concentrated ammonium hydroxide (more than 5 *N*) is used in this treatment, the aluminum hydroxide obtained is shown by microscopic observation to have the crystalline form. The purity of aluminum hydroxide thus treated increases with the amount of ammonium hydroxide used and with longer treatment; the concentrations of ammonia have a marked influence on the properties of the products but little influence on the purity. **VIII.** *Ibid.*, pp. 738–43; Supp. Binding, p. 355B.—A. performed microscopic and X-ray observations and measured the volume of precipitates. A pure and large crystalline form of aluminum hydroxide which may be readily filtered and washed was obtained; its volume is nearly equal to that of aluminum trihydrate (α-$Al_2O_3 \cdot 3H_2O$) (Japan. 105,390). The factors and the relations between the conditions of treatment and the purity of products are brought out clearly. The amount of NH_4OH used must be 1.5 times or more of chemical equivalent and the concentration of ammonium hydroxide used must be more than 4 *N*. This procedure is technically profitable because of its high reaction velocity and the high purity of its products. **IX, Preparation of the crystalline hydrate of aluminum hydroxide.** *Ibid.*, **43** [5] 346–51 (1940); Supp. Binding, p. 145B.—The author has published the method of preparation of the crystalline hydrate of alumina from aluminum sulfate or ammonium alum solution by first passing ammonia gas through it to neutralize it under high pressure and then heating. This alumina is filterable and has less trace of the SO_4 radical than the alumina described in Part VIII. It is identified with γ-$Al_2O_3 \cdot H_2O$ (boehmite) by the X-ray diffraction pattern. A. describes studies on the nature of prepared hydrate of alumina, giving the solution concentrations used, reaction temperatures, reaction pressures, and the charging amounts of ammonia. These studies were made to determine the most profitable conditions of obtaining the crystalline aluminum hydrate. For Parts V and VI see *Ceram. Abs.*, **19** [1] 15 (1940). M.T.

SEPARATE PUBLICATION

Slag Action of Alkalis on Refractories. THOMAS L. HURST. *Amer. Refrac. Inst. Tech. Bull.*, No. 75, 7 pp. (July, 1940).—Alkalis in their various forms and in combination with other agents comprise an important group of

materials which slag and otherwise affect refractories. The alkalis which are most often encountered are sodium and potassium, the common compounds of these being soda and potash. The effects of such alkalis are increased by having present at the same time moisture and volatile iron compounds. Fuels such as oil and coal are likely to contain significant quantities of alkalis which can do appreciable damage. The effects of potash and soda vapors, vapor from potash-silica glass, and vaporized potassium or sodium chloride as well as sodium carbonate vapor are pointed out. In general, hard firing and low porosity increase the resistance of the refractory to absorption of the vapors and dimensional expansion. H.E.S.

PATENTS

Abrasion resistant furnace lining. R. C. Benner and G. J. Easter (Carborundum Co.). U. S. 2,220,701, Nov. 5, 1940 (March 20, 1937).—In a lining for a rotary lime or Portland cement kiln, a zone formed of dense, hard castings composed essentially of crystalline alumina.

Basic refractory materials. P. Imbert, L. Veaux, and P. Pallier. Brit. 527,024, Oct. 16, 1940 (March 28, 1939).

Chemically bonded refractory. F. E. Lathe, N. P. Pitt, and Lisle Hodnett (Canadian Refractories, Ltd.). U. S. 2,218,242, Oct. 15, 1940 (April 24, 1937).—In the preparation of chemically bonded plastic and granular materials, the method comprises uniformly mixing a soluble silicate and, as an antimigration agent, at least one of the carbonate and bicarbonate salts of sodium and potassium with the material to be bonded, the proportion of the antimigration agent being not less than substantially 0.4% nor more than substantially 2% of the material to be bonded, to cause the formation *in situ* of a continuous, gelatinous, and siliceous structure containing in undecomposed form a portion of the soluble silicate. **U. S. 2,218,243,** Oct. 15, 1940 (April 24, 1937; April 17, 1939).—In the preparation of chemically bonded plastic and granular materials, the method comprises uniformly mixing with the material to be bonded a soluble silicate and not less than substantially 0.4% nor more than substantially 2% of the material of at least one of the nitrite and nitrate salts of sodium and potassium to inhibit migration of the silicate within the mass and insure uniform bonding of the latter. **U. S. 2,218,244,** Oct. 15, 1940 (April 24, 1937; April 17, 1939).—In the preparation of chemically bonded plastic and granular materials, the method comprises uniformly mixing with the material to be bonded a soluble silicate and not less than substantially 0.4% nor more than substantially 2% of an alkali metal chlorate to inhibit migration of the silicate within the mass and insure uniform bonding of the latter.

Firebrick and method of making. E. H. Van Schoick (Chicago Retort and Fire Brick Co.). U. S. 2,219,606, Oct. 29, 1940 (March 13, 1939).

Furnace walls. Ivor Power Specialty Co., Ltd., and S. R. Green. Brit. 527,265, Oct. 16, 1940 (April 5, 1939).

Metal-cased refractory. V. M. Goldschmidt. U. S. 2,216,813, Oct. 8, 1940 (Aug. 25, 1938).—A composite refractory article for use in furnaces comprises a preformed refractory body formed from magnesium orthosilicate material and a sheet metal sheath associated with the body.

Mortarless furnace brickwork. Österreichische Magnesit Akt.-Ges. Brit. 525,238, Sept. 4, 1940 (March 8, 1938).

Producing pure alumina. A. S. Burman. U. S. 2,217,099, Oct. 8, 1940 (Sept. 7, 1937).

Refractory material. J. S. Withers (J. D. Sullivan). Brit. 527,179, Oct. 16, 1940 (April 3, 1939). P. B. Sillimanite Co., Ltd., A. R. Lucas, and W. G. Wagner. Brit. 526,414, Oct. 2, 1940 (Feb. 10, 1939).

Refractory and method of making. C. J. Kinzie and Eugene Wainer (Titanium Alloy Mfg. Co.). U. S. 2,220,411, Nov. 5, 1940 (Feb. 17, 1939).—A composition suitable for forming refractory masses comprises a major proportion of a refractory material and a minor proportion of a preformed zirconate of a metal taken from the group consisting of lithium, sodium, potassium, magnesium, calcium, barium, and strontium. **U. S. 2,220,412,** Nov. 5, 1940 (Feb. 17, 1939; April 13, 1940).—A composition suitable for forming refractory masses comprises a major proportion of a refractory material and a minor proportion of a preformed material taken from the group consisting of zinc zirconate, aluminum zirconate, zinc zirconium silicate, and aluminum zirconium silicate. M. Y. Seaton and H. H. Hartzell (Westvaco Chlorine Products Corp.). U. S. 2,218,485, Oct. 15, 1940 (Jan. 17, 1938).—The method of maintaining and repairing basic open-hearth furnace bottoms comprises supplying to the bottoms a mixture of two different materials in granular form, one of the materials containing 65 to 90% MgO and smaller amounts of silica, alumina, and lime in such proportions that the material softens at temperatures between 2500° and 2800°F., the other of the materials containing a smaller amount of MgO and sufficient CaO to convert all the silica and alumina in both components into calcium orthosilicate and tricalcium aluminate and to convert at least part of any iron oxide present into calcium ferrite, and subjecting the mixture to normal furnace temperatures for a period sufficient to cause the first of the materials to soften and initiate reaction with the other material, thereby forming a refractory mass bonded to the adjacent portions of the furnace bottom and adapted to support loads of 20 lb. per sq. in. at temperatures exceeding 3000°F. J. D. Morgan (Power Patents Co.). U. S. 2,220,019, Oct. 29, 1940 (Feb. 11, 1939).—A refractory product comprises the high temperature reaction product of a zirconium mineral and 1 to 2% by weight of an asbestos mineral.

Refractory slabs for building the checkerwork of Cowper stoves and like regenerators. A. Lermer. Brit. 527,248, Oct. 16, 1940 (April 5, 1938).

Terra Cotta

Glazed tile construction. D. F. Albery. *Ceram. Age,* **34** [4] 107 (1939). F.G.H.

Slip-house practice in glazed-tile production. W. D. Meredith. *Trans. Brit. Ceram. Soc.,* **39** [6] 163–77 (1940). R.A.H.

Terra cotta as facing material. Joseph Dean. *Clay Prod. Jour. Australia;* abstracted in *Ceram. Age,* **36** [2] 44 (1940).—The use and the manufacture of terra cotta are briefly described. F.G.H.

PATENT

Border tile for covering walls including corners and recesses of walls. L. Bloch. Brit. 525,752, Sept. 18, 1940 (Feb. 28, 1939).

Whiteware

Material having a negative resistance/current characteristic. Metropolitan-Vickers Electrical Co., Ltd. *Jour. Sci. Instruments,* **17** [6] 166 (1940).—Metrosil, a ceramic material, has a negative resistance/current characteristic which is defined by the equation $V = CI^{\beta}$, where V = applied voltage, I = current flowing, and C and β (constant and exponent) are constant for one piece of Metrosil at a particular temperature. Change of resistance with voltage is instantaneous and is not due to chemical change or breakdown phenomena of any kind. Increase in temperature lowers the value of the constant but does not change the value of the exponent. The ma-

terial is stable to a red heat and is mechanically strong. The exponent may be given values of 0.21 to 0.40 by changes in the manufacturing process. Originally used in lightning arresters and surge suppressors, it is now applied in providing overload protection for electrical instruments, in giving increased sensitivity to voltage regulators, as a voltmeter shunt to give a contracted scale at the higher readings, in producing harmonics and "peaky" wave forms, in making nonlinear potential dividers, and in producing constant voltage valve circuits. It is supplied in disks 1 to 6 in. in diameter and 0.04 to 1 in. thick and in other special shapes. J.L.G.

Particle-size distribution of ingredients versus body properties. J. H. KOENIG. *Bull. Amer. Ceram. Soc.*, **19** [11] 424–30 (1940).—15 figures, 30 references.

Producing ceramic sanitary ware in one firing. A. RAZIN. *Prom. Stroitel. Materialov*, **2** [4–5] 88–92 (1940).—Semivitreous ware is obtained from a batch constituted to obtain lowered sintering properties which eliminate the deformation completely. The water absorption of the finished ware should not exceed 7 to 8%. The firing takes place at about 1200°. Special attention must be paid to the correct glazing of the ware. P.B. & E.S.

Properties of ceramic diaphragms. S. SANADA. *Jour. Soc. Chem. Ind. Japan*, **42** [9] 625–27 (1939); Supp. Binding, p. 314B.—S. investigated the properties of plate-formed ceramic diaphragms made in Japan. Chemical analyses and tests for density, porosity, permeability, resistance to acids and alkalis, and diffusion resistance were made, and the number of pores and their diameters were measured according to Eucken's calculation (Chemical Engineer (Der Chemie-Ingenieur), Vol. I, Part 2, p. 252; *Ceram. Abs.*, **12** [10–11] 388 (1933)) and the report of Stender (*Trans. Electrochem. Soc.*, **67**, 51 (1935)). The values of α ($\alpha = P_{cal.}/P_{obs.}$, where $P_{cal.}$ represents the diffusion degree by calculation, while $P_{obs.}$ is that by observation) obtained from measurements of electrical resistance coincided with those obtained from measurements of diffusion. M.T.

Slip-house technique in general earthenware production. J. A. JOHNSON AND H. L. STEELE. *Trans. Brit. Ceram. Soc.*, **39** [6] 182–97 (1940).—A description of a slip-house technique is given, including the testing of clays, the preparation of plastic clay, the preparation of the casting slip, and the plant layout. R.A.H.

Talc as a ceramic raw material. HANS THURNAUER. *Ceram. Age*, **35** [5] 146–48 (1940).—T. describes uses of the mineral talc as carving stone and especially as an insulating and refractory material. Powdered talc is used extensively in ceramic bodies; steatite bodies contain powdered talc as the chief raw material. Smaller amounts of talc, between 20 and 40%, are incorporated in cordierite bodies, which are characterized by very low coefficient of thermal expansion. The positions of both steatite and cordierite bodies in the triaxial phase diagram $Al_2O_3 \cdot MgO \cdot SiO_2$ are shown. Other uses of talc in ceramic bodies are mentioned. Illustrated. F.G.H.

SEPARATE PUBLICATION

Laboratory Porcelain. British Standard Test No. 914—1940. BRITISH STANDARDS INST., London. Price 2s.—*Shape, etc.:* Good hard porcelain for laboratory use should withstand fairly sudden changes of temperature without fracture. The body should be nonporous, and the glaze must be free from defects. Irregularities in shape and finish should be absent. The weights of vessels of similar size and shape should be reasonably consistent. *Stain:* After immersion for 18 hr. in a 0.5% solution of eosin, no stain should be visible with a hand lens. *Temperature change:* To test resistance to sudden changes in temperature, a crucible or other vessel is placed in an electrically heated tube of special design and, after 15 min. at 240°C., is allowed to fall into a bucket of water. *Glaze:* Small fragments of the ware are placed in two or more crucibles of the same material in such a manner that contact between glaze and biscuit is ensured. After gentle ignition and cooling, the vessels are weighed and then heated for 2 hr. in a muffle at 950° to 1000°C. After this treatment there should be no change in weight and no adhesion of the pieces to each other. *Resistance to acid:* Two or more weighed dry dishes are filled with constantly boiling hydrochloric acid and heated in a steam bath for 4 hr. After they are cooled, washed, dried, and reweighed, the loss should not exceed 1 mgm. per sq. dm. *Resistance to alkali:* (*a*) The dishes used for testing resistance to acid are three-quarters filled with normal sodium carbonate solution, covered with a watch glass, and heated for 4 hr. at 100°C. in an atmosphere of steam. They are allowed to cool and are dried and reweighed. The increase in weight should not exceed 10 mgm. per sq. dm. The volume of solution should not increase more than 10%. (*b*) The same dishes, when similarly treated with 5% caustic soda, should not lose more than 60 mgm. per sq. dm. A.B.S.

PATENTS

Application of ceramic transfers or prints to pottery, etc. DOULTON & CO., LTD., AND C. BAILEY. Brit. 527,173, Oct. 16, 1940 (April 3, 1939).

Artificial teeth. DENTISTS' SUPPLY CO. OF NEW YORK. Brit. 526,017, Sept. 18, 1940 (Dec. 23, 1938).

Artificial tooth. SIMON MYERSON. Can. 391,449 to 391,451, Sept. 24, 1940 (Nov. 30, 1938). G.M.H.

Ceramic body. T. G. MCDOUGAL, A. H. FESSLER, AND KARL SCHWARTZWALDER (General Motors Corp.). U. S. 2,218,584, Oct. 22, 1940 (March 31, 1937).—A spark plug insulator made by sintering into a dense, nonporous structure a composition consisting of aluminum oxide together with 0.5% to 20% chromium oxide.

Ceramic material. LOUIS NAVIAS (General Electric Co.). U. S. 2,220,774, Nov. 5, 1940 (Dec. 30, 1937).—A ceramic mix especially adapted for the production of matured ceramic materials having a high dielectric constant and a low power factor, the mix containing, by weight, about 40 to 95 parts titanium dioxide and about 60 to 5 parts of a clay-free inorganic binder, the binder comprising calcium titanium silicate in the binder. **U. S. 2,220,775,** Nov. 5, 1940 (Dec. 30, 1937).—A ceramic mix especially adapted for the production of matured ceramic materials having a high dielectric constant and a low power factor, the mix containing, by weight, about 40 to 95 parts titanium dioxide and about 60 to 5 parts of a clay-free inorganic binder adapted to bond the titanium dioxide into a dense mass when the mix is fired to vitrification, the binder comprising a preformed, substantially alkali-free titania glass.

Dentifrice. H. D. LONG (Pepsodent Co.). U. S. 2,216,821, Oct. 8, 1940 (Nov. 4, 1938).—A dentifrice composition consisting predominantly of insoluble sodium metaphosphate and including a suitable percentage such as 1 to 7% of magnesium compound chosen from the group consisting of magnesium oxide, magnesium hydroxide, magnesium carbonate, alkaline magnesium silicate, trimagnesium phosphate, and monomagnesium phosphate.

Forming fluid pervious ceramic bodies. E. T. HERMANN. U. S. 2,215,962, Sept. 24, 1940 (July 26, 1937).—The method of preparing a fluid pervious ceramic body comprises subjecting a body of argillaceous material to plastic subdivision to form a plurality of discrete argillaceous particles, causing the particles to fall downwardly toward a receiving member, directing a mist of aqueous plasticizing medium transversely to the direction of fall of the particles and into contact therewith to produce a plastic surface condition thereof, collecting the particles at the position of the receiving member to form a pervious mass having a multiplicity of internal voids and in which the particles are arranged in contacting intersupporting plastically interbonded relation, and subjecting the pervious mass to a firing operation to form an integral ceramic body.

High tension electric insulator. H.-F. SCHWARTZ (C. Lorenz A.-G.). U. S. 2,217,420, Oct. 8, 1940 (May 10, 1938).—A stand-off insulator of the type supported from below.

Joint for ceramic materials. CHARLES MOLYNEUX (K. L. G. Sparking Plugs, Ltd.). Can. 390,994, Aug. 27, 1940 (April 5, 1939). G.M.H.

Manufacture of ceramic dielectrics. WERNER RATH AND HANS HANDREK (Porzellanfabrik Kahla). U. S. 2,215,478, Sept. 24, 1940 (Feb. 4, 1935).—The method of producing a ceramic dielectric comprises depositing upon a suspension of ground titanium dioxide a precipitate of an organic titanium soap obtained by chemical precipitation, separating the solid mixture so produced from the suspending medium, pressing the mass into a form suitable for condenser dielectrics, and then sintering the shaped mass to a solid body, the proportions of the materials being such that the titanium dioxide comprises at least about 80% of the dielectric.

Manufacture of spark plugs. J. E. POLLAK (H. A. Richardson). Brit. 526,347, Oct. 2, 1940 (March 14, 1939).

Spark plug. CHARLES M. CARINGTON (K. L. G. Sparking Plugs, Ltd.). Can. 391,505, Sept. 24, 1940 (May 25, 1939). OTTO C. ROHDE (Champion Spark Plug Co.). Can. 390,007, July 16, 1940 (May 16, 1936; in U. S. Feb. 13, 1936). G.M.H.

Spark plug. E. S. TWINING AND B. H. SIBLEY (Champion Spark Plug Co.). U. S. 2,217,825, Oct. 15, 1940 (Aug. 25, 1939).

Spark plug insulator manufacture. EMIL KLINGLER AND EUGEN DREHER (Robert Bosch G.m.b.H.). Can. 391,997, Oct. 15, 1940 (Nov. 12, 1937). G.M.H.

Spark-plug insulators and method of making. CHAMPION SPARKING PLUG CO., LTD. Brit. 526,002, Sept. 18, 1940 (May 27, 1938).

Vitreous body. MARCELLO PIRANI AND J. H. PARTRIDGE (General Electric Co.). U. S. 2,219,331, Oct. 29, 1940 (Dec. 1, 1937).—A refractory vitreous gas-impervious material consists of silica (SiO_2) 94, thoria (ThO_2) 4, and beryllia (BeO) 2%.

Equipment and Apparatus

Apparatus and method for the determination of porosity in refractory materials. GILBERT E. SEIL, BRADFORD S. TUCKER, AND H. A. HEILIGMAN. *Jour. Amer. Ceram. Soc.*, **23** [11] 330–33 (1940).—4 figures, 4 references.

Ball wear in ball-mill grinding. S. MÖRTSELL. *Jernkontorets Ann.*, **124** [1] 1–38 (1940).—M. points out the importance of the wear of balls in ball mills, especially with regard to the grinding of ores. He discusses Davis's theory that the wear of any ball in a mill is proportional to its weight and describes his own tests which show that the wear of a ball in a ball mill is directly proportional to the grinding time and is therefore constant per unit of time for each ball making up a charge and is independent of its size. Tests were carried out with forged and cast steel cubes of different dimensions, which were put in a ball mill for grinding iron ore for various periods up to 1700 hr. In other tests, balls of three sizes were used in a small laboratory mill for periods of about 400 hr. For comparison purposes, M. uses the symbol μ to represent the coefficient of wear, which he defines as the reduction in diameter in thousandths of a millimeter per hour of continuous grinding. The results of these tests show that μ is constant for a charge of balls used for continuous grinding and that the wear of any ball is not proportional to its weight but to the area of its surface. The introduction of the coefficient μ is useful in the study of the efficiency of ball and rod mills; it also provides a means of comparing and selecting balls of different qualities of steel. M. presents calculations based on the above relationship between ball wear and surface area by which the number and size of the balls required can be determined when μ is known. He considers the causes of nonuniform wear of balls, and, as further evidence in support of his theory that μ is constant for all the balls of a particular charge without regard to their size, he quotes data on the size and wear of balls used in a cylindrical mill at the ore-concentration plant at Rönnskär (north Sweden). He discusses the investigations of Gross ("Crushing . . . ," *Ceram. Abs.*, **17** [8] 286 (1938)) relating to the influence of the grain size of the ore on the wear of the balls and shows that the results obtained by various investigators, which seem to support Davis's theory, do not in actual fact contradict M.'s theory that the total wear of a charge of balls is equally distributed over the total surface area of the balls. R.A.R.

Better mill lighting. L. C. GREENE. *Textile World*, **90**, 72 (Jan., 1940).—Failure to take advantage of efficient equipment and engineering services to improve inadequate lighting is inexcusable. With a new system installed in a mill, current consumption is only 75% above that of the old system, but foot-candle tests at the working position of operators show an improvement of 156%. The new system has increased production, reduced spoilage, promoted cleanliness, improved the product, and assisted materially in the prevention of accidents. F.S.M.

Borod doubles life of pug-mill knives. R. G. CROUCH. *Fusion Facts;* reprinted in *Ceram. Age*, **36** [3] 86–87 (1940).—C. describes the application of hard-facing metals to pug-mill knives, brick dies, mixers, wet and dry pans, crushers, and other brick-plant equipment. Illustrated. F.G.H.

Brick-measuring device. GILBERT E. SEIL. *Bull. Amer. Ceram. Soc.*, **19** [11] 437–38 (1940).—2 figures.

Centrifuge tube for heavy-mineral separation. W. E. BERTHOFF, JR. *Jour. Sed. Petrology*, **10** [2] 94 (1940). G.M.H.

Constant temperature control apparatus, utilizing a special type of voltage regulator. J. S. BLAIR. *Jour. Sci. Instruments*, **17** [8] 203–208 (1940).—The apparatus, designed for use in constant-temperature rooms, will supply a constant energy input to the furnace to compensate for unavoidable mains fluctuations. Constant input is maintained by alternately raising and lowering the input voltage between two limits. A resistance is switched in or out in such a way that the mean R.M.S. value of the voltage (or the current) is constant. Electrical and mechanical construction details are described. Typical temperature curves obtained with the apparatus are reproduced. 7 figures. J.L.G.

Construction of platinum thermometers and determination of their basic points. W. H. KEESOM AND B. G. DAMMERS. *Kamerlingh-Onnes Lab., Leiden, Communication*, No. 239*d*; *Physica*, **2**, 1051–58 (1935); abstracted in *Proc. Acad. Sci. Amsterdam*, **38** [9] 958 (1935).—In 1927 the Seventh General Conference of Weights and Measures fixed a temperature scale (the International Temperature Scale) which, for temperatures from −190° to +660°C., depends on readings of the platinum thermometer. As a result of an analysis of the experimental basis on which the definition of the International Temperature Scale rests, the Kamerlingh-Onnes Laboratory decided not to accept that scale and continued to compare its platinum thermometers directly with the helium thermometer. It decided to construct, from wires of different origin, platinum thermometers which satisfy the exigencies mentioned in the definition of the International Scale and to compare them from 0° to −183°C. with the helium thermometer. The details of construction and measurement of the basic points are given. The optimum annealing temperature lies at 840° to 850°C. The oxygen point was taken at −182.98$_5$°C., derived as an average of previous Leiden determinations recalculated with recent values of the fundamental pressure coefficient and of the second virial coefficients of helium. A new determination gave −182.98$_6$°C. The accuracy of the calibration of the platinum thermometer at the ice, steam, and oxygen points appears to be about 0.002 to 0.003°. W.L.

Determination of the thermodynamic scale of temperature below 1°K. by magnetic measurements. H. B. G.

CASIMIR AND W. J. DE HAAS. *Physica*, **7** [1] 70–78 (1940).—An analysis is given of the errors which may be involved in the method of de Haas and Wiersma for obtaining the thermodynamic scale of temperature below 1°K.; an estimate of these errors may be obtained from a fairly rough determination of adiabatic *M, H* curves.. As an example, a few measurements on iron ammonium alum are discussed. W.L.

Direct reading humidity meter. ANON. *Engineering*, **147**, 759 (1939).—The instrument can be used for the following temperature ranges: −5° to +20°, 10° to 40°, and 40° to 120°C. Within these ranges the maximum error is ±3% with a relative humidity of 10 to 100%. At any given constant temperature the accuracy is ±1%. Dry and wet bulbs are used in the instrument. B.C.R.

Drying and power problems in clayworks. LEON BAILLY. *Claycraft*, **13** [3] 77–79 (1939); reprinted in *Ceram. Age*, **35** [3] 72–73 (1940).—B. analyzes the process of drying from the standpoint of economy. Emphasis is placed on the establishment of an equilibrium between power requirements and drying requirements. F.G.H.

Dry lubrication solves high-temperature operating problems at Champion Spark Plug Co. plant. ANON. *Ceram. Age*, **35** [3] 71 (1940).—Colloidal graphite is used to lubricate both chain conveyers and kiln-car wheel bearings. F.G.H.

Dry separation of minerals. THEODORE KIPP. *Can. Mining & Met. Bull.*, No. 342, pp. 398–406 (1940).—Dry gravity separation of minerals of almost identical specific gravity is now possible commercially. Screen openings should vary directly as the ratio between the specific gravities of the substances to be separated. This greatly simplifies the matter of screen classification. Air-flotation tables give excellent results in concentrating such minerals as andalusite, mica, feldspar, gypsum, etc. An ordinary magnetic separator may sometimes give better results in the case of certain iron-bearing minerals or ores. If the iron-bearing mineral is feebly magnetic, concentration may be obtained by the use of a high-intensity or induction magnetic separator. Electrostatic separation is available in cases where none of the other methods described gives satisfactory results. G.M.H.

Furnace for determining refractoriness with a controlled kryptol resistance. V. A. LEBEDEV. *Ogneupory*, **7** [10–11] 705–11 (1939).—The Ukrainian Institute for Scientific Research of Refractory and Acid-Resisting Materials has developed an electric furnace with a regulated resistance for determining refractoriness. With a current of 127 volts, no additional rheostats are needed. With a comparatively small change in the granulometric composition of the kryptol, the furnace can be used with a current of 220 volts. See "Electric . . .," *Ceram. Abs.*, **18** [5] 134 (1939). M.V.C.

High-temperature resistance-type electric laboratory furnaces. WALLACE M. HAZEL AND WILLIAM J. O'LEARY. *Ind. Eng. Chem., Anal. Ed.*, **12** [2] 109–12 (1940).—For high-temperature fusions, ignitions, and combustions, internally wound Alundum-core furnaces, with exposed coiled-wire winding running parallel to the axis of the furnace, are capable of attaining temperatures up to 1500°C., depending on the resistance wire used. Chromel and Nichrome are satisfactory for temperatures below 1100°C.; from 1100° to 1300°C., Kanthal has been found serviceable; from 1300° to 1500°C., a platinum or platinum-rhodium winding is most satisfactory; molybdenum or tungsten, operated in an atmosphere of hydrogen, may be used for higher temperatures. Details of furnace construction and instructions on methods of operation are given. Illustrated. F.G.H.

Optical pyrometer. ELLIOT BROTHERS, LTD. *Jour. Sci. Instruments*, **17** [7] 190 (1940).—A disappearing filament type optical pyrometer with ranges of 800° to 1400°C., 1200° to 2200°C., or both is presented. Price of the single-range pyrometer is £29 11s complete. 1 figure. J.L.G.

Optical pyrometer for general use. J. G. HAGEDORN. *Physica*, **6** [10] 1126–28 (1939).—The construction of an optical pyrometer with the highest possible transmission is described. It possesses a large field of view and a magnification such that it is suitable for measuring the brightness of very small objects. Two diaphragms are employed instead of one, which makes possible the use of an aperture three to four times larger. W.L.

Optical smoothness meter for evaluating the surface finish of metals. J. GUILD. *Jour. Sci. Instruments*, **17** [7] 178–82 (1940).—A beam of light is concentrated on a small area of the surface to be tested. All of the reflected light is collected inside a small integrating sphere whose internal illumination is then indicated by a photocell of the rectifier type connected to a galvanometer. A shutter in the sphere enables the specularly reflected light to be distinguished from the diffusely scattered light. The ratio of the specular light to the total light reflected in all directions affords a sensitive means of comparing surfaces for smoothness. 4 figures, 1 table. J.L.G.

Photoelectric cell for measuring the temperature of flames. R. MECKE AND H. KEMPTER. *Z. Tech. Physik*, **21**, 85–88 (1940).—The cell used for measuring the temperature contains cesium. It may be used for 1000°K. and higher temperatures and is claimed to be superior to the photographic plate. W.M.C.

Photoelectric sedimentation method of measuring particle-size distribution and efficiency of dust-removal apparatus. K. GÖSELE. *Forsch. Gebiete Ingenieurw.*, **10** [5] 235–45 (1940).—G. describes a method for determining the size distribution of the particles in a dusty atmosphere based on the measurement of the rate of fall of the dust particles in an enclosed space. A beam of light is passed through the sedimentation tube, and the intensities of the transmitted light and the Tyndall light scattered at right angles are measured by vacuum photocells with amplifiers. For particles greater than about 1 μ, the scattered light intensity is proportional to the surface area. The method is practical for particles measuring between 1 and 30 μ and for dust concentrations above 10 mgm./cu. m. A check with the usual microscopic method was very satisfactory. It is essential that the particles have the same specific gravity and the same optical properties. The application of the apparatus for measuring the efficiency of dust-removal apparatus is described. J.M.N.

Psychrometric chart, application and theory: XV. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **12** [8] 486–88 (1940).—G. presents Appendixes 9 and 10, which conclude the series. 2 figures, 2 tables. For Part **XIV** see *Ceram. Abs.*, **19** [10] 240 (1940). J.L.G.

Recirculating air heating applied to ceramic drying. ROY HUMMEL AND ROBERT TWELLS. *Bull. Amer. Ceram. Soc.*, **19** [11] 434–37 (1940).—5 figs., 15 references.

Selecting and maintaining rubber belts. JAMES ADAMS, JR. *Power*, **84** [3] 150–52 (1940).—Practical hints are given on the construction, application, and care of flat-rubber and multiple V belts. Illustrated. F.G.H.

Simpler operation for flue-dust sampler. P. H. HARDIE. *Power*, **84** [6] 369 (1940).—Details of construction and operation are described and illustrated. F.G.H.

Sink and float methods of concentration. F. B. MITCHELL. *Mine & Quarry Eng.*, **4** [4] 135–37 (1939).—M. presents a short description of the development and application of heavy-liquid separation for coal cleaning and metalliferous-ore concentration. See "Nonsulfide . . .," *Ceram. Abs.*, **18** [10] 280 (1939). A.P.S.

Slag testing furnace. J. C. MCMULLEN. *Bull. Amer. Ceram. Soc.*, **19** [11] 439–42 (1940).—5 figs., 3 references.

Special stopper for mercury volumeter. G. E. SEIL, B. S. TUCKER, AND H. A. HEILIGMAN. *Jour. Amer. Ceram. Soc.*, **23** [12] 354 (1940); see *ibid.*, [11] 330–33.

Strain viewer for glass articles. R. W. DOUGLAS AND R. L. BREADNER. *Jour. Sci. Instruments*, **17** [7] 187–88 (1940).—A light source, Polaroid disk, sensitive tint plate, diffusion screen, and Polaroid spectacles are employed in the usual manner. 2 figures. J.L.G.

Suggestions for the facilitation of grain count with the petrographic microscope. WILLIAM A. WHITE. *Jour. Sed. Petrology*, **10** [2] 91–93 (1940).—A new cross-hair arrangement and a spring-activated stage lock are used to

eliminate observations made in the peripheral parts of the field of vision. G.M.H.

Temperature measurement with blocking-layer photocells. B. M. LARSEN AND W. E. SHENK. *Jour. Applied Physics*, **11**, 555–60 (1940).—The characteristics of photronic-cell recording instruments are described as applied to measurements of temperatures from 1300° to 1750°C. in open-hearth furnaces. A.P.

Testing dust collectors. JOHN E. WATSON. *Power*, **83** [11] 668–70 (1939).—Practical methods for obtaining accurate data on dust-collector efficiency are described. Illustrated. F.G.H.

Theoretical aspect of crushing and grinding. F. B. MICHELL. *Mine & Quarry Eng.*, **4** [11] 359–64 (1939).—M. reviews the theories of Rittinger and Kick in the light of recent experimental evidence and discusses their bearing on comparative efficiency calculations in practice. A.P.S.

Triple-lens mercury-in-glass thermometers. SHORT AND MASON, LTD. *Jour Sci. Instruments*, **17** [8] 211 (1940).—Binoc thermometer tubing has (1) increased angle of vision, (2) a wide background which gathers light through three lens ridges, and (3) no bore reflection. Both eyes can be used at close range to read values with binocular vision. J.L.G.

Two-color optical pyrometer. H. W. RUSSELL, C. F. LUCKS, AND L. G. TURNBULL. *Jour. Optical Soc. Amer.*, **30**, 248–50 (1940).—Monochromatic optical pyrometers fail if either the emissivity of the source or the transmission of the intervening space is unknown or variable. The ratio of the intensities of two radiations of different wave lengths, however, provides a direct measure of the temperature. A portable and a recording apparatus are described. They operate on sources above 1000°C. with errors of about 10°C. See "Color. . . ," *Ceram. Abs.*, **18** [4] 106 (1939). A.P.

Venturi ejector for handling air: II, Analysis and performance formulas. F. F. KRAVATH. *Heating & Ventilating*, **37** [8] 46–49 (1940).—The working principle of the ejector is explained in detail with diagrams. Formulas are derived for calculating the performance of the ejector. This apparatus is best suited for eliminating any material which is extremely corrosive, explosive, hot, or sticky. It may also be used for abrasive materials or for nuisances or hazards which occur only infrequently. The ejector may be operated by steam, water, or exhaust gases, the latter, when available under a few inches of water gauge pressure, proving especially economical. For Part I see *Ceram. Abs.*, **19** [10] 247 (1940). F.S.M.

BOOKS AND SEPARATE PUBLICATIONS

Air Flow at Discharge of Fan Pipe Lines in Mines: I, Ten-Inch Line in Development End. G. E. MCELROY. *U. S. Bur. Mines Repts. Investigations*, No. 3531, 14 pp. Free.—Preliminary data are given on the effect of the velocity of discharge, size and shape of pipe, and adjacent walls on the air-flow distribution of fan pipe lines. R.A.H.

Alloy Cast Irons. AMERICAN FOUNDRYMEN'S ASSN., GRAY IRON DIV. American Foundrymen's Assn., Chicago, 1939. 270 pp., 111 charts and illustrations, 73 tables, 25-page bibliography. Reviewed in *Glass Ind.*, **20** [7] 272 (1939). A.P.

Electrostatic Dust Sampler as Used in Sampling Lead Fumes. *Penna. Dept. Labor & Ind., Safe Practice Bull.*, No. 57, 8 pp. (Nov., 1939).—A detailed description of the electrostatic dust precipitator and its use in industrial hygiene surveys is presented. Tests show that this instrument is practically 100% efficient in removing particulate matter from the air. Methods of analyzing fumes collected by this method are discussed, and various aspects of lead poisoning are mentioned briefly. F.S.M.

Minerals Used in Welding. OLIVER C. RALSTON AND M. W. VON BERNEWITZ. *U. S. Bur. Mines Information Circ.*, No. 7121, 56 pp. Free.—Minerals that enter welding-rod coatings and fluxes (grade and quantities), various methods of welding, metals that can be welded, and some common minerals used are discussed. A list of manufacturers of welding rods and fluxes is included. R.A.H.

Testing Respiratory Protective Equipment for Approval. H. H. SCHRENK. *U. S. Bur. Mines Information Circ.*, No. 7130, 9 pp. Free.—S. gives a brief review of the testing of respiratory equipment for approval which includes general requirements, basic considerations of schedules, essentials of test requirements, and past requirements. R.A.H.

PATENTS

Apparatus for distributing granular material and method of distribution. C. F. GEIGER, C. P. CLAPP, AND W. C. KEMPF (Carborundum Co.). U. S. 2,219,954, Oct. 29, 1940 (Jan. 18, 1937).

Apparatus for measuring spectral reflectance. PHILIP NOLAN (Institute of Paper Chemistry). Can. 389,743, July 2, 1940 (April 21, 1938; in U. S. April 23, 1937). G.M.H.

Brick press. E. B. HAGAR (G. W. Reed). U. S. 2,218,196, Oct. 15, 1940 (June 21, 1937).

Continuous centrifugal separator and clarifier. A. F. HOWE (B H and M Co.). U. S. 2,218,532, Oct. 22, 1940 (March 5, 1937).

Electrically heated tubular melting furnaces. HENLEY EXTRUSION MACHINE CO., LTD., P. DUNSHEATH, AND F. T. GRIFFITHS. Brit. 525,192, Sept. 4, 1940 (Feb. 18, 1939).

Filter press. RICHARD SELIGMAN AND HUGH F. GOODMAN (Aluminium Plant & Vessel Co., Ltd.). Can. 391,921, Oct. 15, 1940 (April 21, 1938). G.M.H.

Manufacturing lugged pottery ware. W. J. MILLER. U. S. 2,217,346, Oct. 8, 1940 (March 29, 1935; Nov. 16, 1939).

Screening and purifying machine. D. M. SHALER (J. M. Shaler). U. S. 2,217,710, Oct. 15, 1940 (Oct. 6, 1938).—In a screening and purifying machine, a vibratory screen frame having screens ranging from relatively fine at the head end of the machine to relatively coarse at the tail end thereof, a vibratory receiving pan under the screen frame.

Silk screen printing apparatus. H. J. HICKS (Precision Finishing Machine Corp.). U. S. 2,217,366, Oct. 8, 1940 (Aug. 4, 1939).

Sintering or calcining apparatus. NIKOLAI AHLMANN (F. L. Smidth & Co.). Can. 390,707, Aug. 13, 1940 (Jan. 19, 1939). G.M.H.

Slab separating device. M. F. PETTLER. U. S. 2,216,021, Sept. 24, 1940 (May 10, 1940).—A machine for separating fired clay slabs comprises a cutting tool mounted on a flat supporting table, a toothed wheel having a relatively large number of angularly spaced teeth for engagement with one end of the cutting tool, spring means normally biasing the tool away from the teeth of the wheel, and a drive for the wheel to subject the cutting tool to rapid reciprocatory movement when pressed against the wheel.

Kilns, Furnaces, Fuels, and Combustion

A B C's of draft. WILLIAM H. PUGSLEY. *Power*, **84** [8] 522–23; [9] 594–95 (1940).—The fundamentals of draft measurement are clearly described and illustrated. F.G.H.

Burning sawdust in pottery manufacture. K. HIRANO, S. KAMEI, AND S. ISIDUKA. *Jour. Soc. Chem. Ind. Japan*, **42** [6] 379–81 (1939); Supp. Binding, p. 199B.—Pine wood has long been used as fuel in pottery manufacture in Japan. Since the Meiji era foreign kilns using coal and liquid fuel such as heavy oil have been introduced. These contain a certain amount of sulfur, however, which discolors the glaze. The use of wood as fuel has been limited because of its low calorific value. The authors have devised a simple method of burning sawdust continuously by

which more heat is emitted, fuel cost is lowered, and the quality of the product is improved. The burning apparatus of the special dome-shaped furnace 3.5 m. in inside diameter is illustrated. Burning is controlled easily and effectively with an oxidizing, neutralizing, or reducing atmosphere. See "Pulverized...," *Ceram. Abs.*, **18** [4] 109 (1939). M.T.

Coking index for rating coals. C. E. PRITCHARD. *Power*, **84** [5] 302–303 (1940).—The use of a coking index in the solution of practical coal-selection problems is considered. F.G.H.

Combustion made easy. WILLIAM MADDOCK. *Power*, **83** [10] 628–29 (1939).—Short cuts in combustion calculations are described. F.G.H.

Development of a small pottery kiln with control of muffle atmosphere. PETER LLOYD. *Trans. Brit. Ceram. Soc.*, **39** [7] 199–205 (1940).—L. describes the development, over a three-year period, of a small gas-fired pottery kiln suitable for experimental work on ceramics and for the work of the artist potter. A temperature of 1300°C. is reached in 9½ hr. Few details of construction but many details relative to control of the furnace atmosphere are given. R.A.H.

Draft in burning practice. T. W. GARVE. *Brick & Clay Record*, **97** [2] 18–21 (1940).—The relative merits of updraft, downdraft, and horizontal draft as evidenced in updraft, downdraft, and continuous kilns are analyzed. Fuel consumptions from actual operations are presented. Illustrated. **Discussion.** J. G. SEANOR AND L. R. WHITAKER. *Ibid.*, pp. 21–22. T.W.G.

Effect of water content on the crushability of brown coal. K. MORIKAWA, T. ISIGURO, AND R. ABE. *Jour. Fuel Soc. Japan*, **19** [209] 125–36 (1940).—Methods of testing for the crushability of coal are discussed. Two methods have been adopted in this investigation: (1) the method of Cross and Hardgrove which compares the crushability of coal by the ratio of the surface area, and (2) the principles of the Rosin and Rammler method by which the results of sieve analysis of the original samples and crushed coal are expressed diagrammatically. The sample used belonged to the Jurassic period, and the fresh sample contained about 40% total water; it deteriorated in air to fine powder, and the water content decreased to 25%. The effects of weathering on the crushability of coal stored on the field were examined. Long storage increases crushability, and rain is an effective factor. The crushabilities of fresh coal and of weathered dry coal were compared by means of the free falling method, the jaw crusher, and the tube mill. Weathered coal is more crushable than raw coal in every case. In crushing in a tube mill, it was found that coal containing about 35% water was easily and finely pulverized at room temperature or at 50° to 55°C. and screened without any trouble. The effect of the addition of water on the crushability of coal in ball mills was also investigated. The addition of water increases the crushability in proportion to the carbonization degree of the coal. The crushability of coal is very complicated and is influenced not only by water content but also by several other factors. Y.K.

Factors affecting the life of kiln furniture in the whiteware industry. GRANT S. DIAMOND. *Bull. Amer. Ceram. Soc.*, **19** [10] 371–78 (1940).—14 figures, 6 references.

Firing fuels in tunnel kilns. GEORGE D. BRUSH. *Bull. Amer. Ceram. Soc.*, **19** [10] 368–71 (1940).—5 figures.

Industrial gas applications. GEORGE M. PARKER. *Gas Age*, **86** [1] 20 (1940).—One of the undesirable features of natural gas as a fuel for industrial furnaces is that it burns with a nonluminous flame, necessitating that all radiation come from the brick walls and roof. In small recuperative furnaces the diffusion-combustion principle has worked satisfactorily, but in larger high-temperature regenerative furnaces it has not functioned so well, probably because of the difficulty in preventing the development of turbulence which breaks up the flame stratification. By a new method, natural gas is cracked to produce a gas of 150 B.t.u. with a high content of finely divided carbon which causes it to burn with a highly luminous flame. Admixture of this gas with natural gas produces a desirable type of gas having the burning properties of producer gas. B.C.R.

Kiln practices in ceramic industries. ANON. *Engineering*, **147**, 525 (1939).—The uses and construction of various types of ceramic kilns are described. B.C.R.

Kiln setting. A. A. THOMPSON. *Claycraft*, **13** [2] 50–51 (1939); reprinted in *Ceram. Age*, **35** [1] 10, 24 (1940).—Fundamentals of brick setting are briefly discussed. F.G.H.

Low-fusion coal. CARL A. MARSHALL. *Power*, **83** [12] 736–37 (1939).—Low- and high-fusion coals are discussed from the standpoints of cost, grindability, and combustion characteristics. Illustrated. F.G.H.

Milwaukee's contribution to pulverized-coal development. HENRY KREISINGER AND JOHN BLIZARD. *Mech. Eng.*, **62** [10] 723–26, 737 (1940).—Illustrated. F.G.H.

Physical chemistry of gas-producer reactions in relation to ceramic firing. A. W. GAUGER. *Bull. Amer. Ceram. Soc.*, **19** [10] 365–68 (1940).—2 tables, 3 references.

Relation of setting face brick in downdraft kilns to heat distribution. FRANK E. LOBAUGH. *Bull. Amer. Ceram. Soc.*, **19** [10] 361–64 (1940).—4 figures, 3 references.

Static chimney draft. ANON. *Power's Data Sheet*, No. 98; *Power*, **84** [9] 613 (1940).—A chart for the determination of the theoretical draft available from a chimney or stack of a given height is presented. F.G.H.

Successful mechanical atomization of fuel oil heavier than Bunker C. G. G. MARTINSON. *Trans. Amer. Soc. Mech. Engrs.*, **62** [7] 543–50 (1940).—M. shows definitely that it is not only possible but practical and economical to burn heavy petroleum oils in properly designed combination coal-and-oil burners in completely water-cooled furnaces, using mechanical atomization under automatic control. Illustrated. F.G.H.

Tunnel kiln for the brick industry. ADOLF ROLLE. *Tonind.-Ztg.*, **63** [55] 631–32 (1939).—The tunnel kiln, hitherto used for fine ceramic ware only, is competing with continuous kilns for brick. The thermal efficiency of the tunnel kiln is superior to that of the continuous-type brick kiln. Gas-fired tunnel kilns produce better quality brick than kilns where coal is dropped down. Fuel consumption in a gas-fired tunnel kiln is 150 kgm. per 1000 brick (German size); another advantage is the reduction in total firing time. Illustrated. F.E.S.

Ventilating and exhaust systems in rotary-kiln operation. ANON. *Ceram. Age*, **35** [2] 39 (1940).—Characteristics of the ventilating and exhaust fans used in a rotary-kiln plant producing 12,000 dishes per 24-hr. day are briefly described. Illustrated. F.G.H.

BOOKS AND SEPARATE PUBLICATIONS

Gas Producers (Les Gazogenes). H. GUILLON. Chaleur et Industrie, Paris, 1939. 126 pp., paper covers. Price Fr. 30. Reviewed in *Glass Ind.*, **20** [9] 336 (1939); see *Ceram. Abs.*, **17** [2] 81 (1938). A.P.

Sampling and Analyzing Coal-Mine Dusts for Incombustible Content. C. W. OWINGS, W. A. SELVIG, AND H. P. GREENWALD. *U. S. Bur. Mines Information Circ.*, No. 7113, 21 pp. Free. R.A.H.

Tests of Salt as a Substitute for Rock Dust in the Prevention of Coal Dust in Mines. H. P. GREENWALD, H. C. HOWARTH, AND IRVING HARTMANN. *U. S. Bur. Mines Repts. Investigations*, No. 3529, 16 pp. Free. R.A.H.

Use of Wetting Agents for Allaying Coal Dust in Mines. IRVING HARTMANN AND H. P. GREENWALD. *U. S. Bur. Mines Information Circ.*, No. 7131, 12 pp. Free.—Wetting agents, their application in coal mines, and tests of wetting agents are described. R.A.H.

PATENTS

Apparatus for feeding fuel into continuous kilns. J. PROCTER. Brit. 527,303, Oct. 16, 1940 (March 31, 1939).

Automatic fuel burning device. M. M. CASTAGNA. U. S. 2,216,109, Oct. 1, 1940 (Nov. 22, 1937).—In a stoker, a combustion pot, means for feeding fuel to the combustion pot, means for feeding air to the combustion pot, a bleeder

duct for relieving some of the pressure of the air being fed to the combustion pot by bleeding a portion of the air to the atmosphere, means controlling the fuel-feeding means, and means responsive to a predetermined maximum velocity of the air passing through the bleeder duct for operating the controlling means to stop the fuel-feeding means.

Ceramic ware firing apparatus. EARL J. HARRIS (Carborundum Co.). Can. 391,993, Oct. 15, 1940 (June 26, 1935).—In an electrically heated kiln, a gaseous jet causes circulation of the gases, the jet being placed to cause circulation in a direction opposite to that normally caused by convection. G.M.H.

Kiln. G. P. FACKT. U. S. 2,215,581, Sept. 24, 1940 (Feb. 28, 1939).—In a kiln having a tunnel therein, a floor supported at its side portions in the tunnel, the kiln having openings through the bottom thereof, and heat-producing means at each opening directed upwardly toward the exposed under face of the floor.

Radiant-heat tube furnaces. W. L. JONES (Electric Furnace Co.). Brit. 526,746, Oct. 9, 1940 (Feb. 18, 1939).

Geology

Adsorption by clay minerals and organic soil colloids. P. SCHACHTSCHABEL. *Kolloid-Beihefte*, **51** [5–7] 199–276 (1940).—The capacity of soils to adsorb cations was attributed to zeolites until Hendricks and Fry (*Soil Sci.*, **29**, 457–79 (1930)) proved that it is due to clay minerals. After discussing the adsorption by clay minerals in general, S. describes his experiments on the base exchange of clay minerals with the chlorides of alkalis and alkaline earths. The clay minerals had been transformed into NH_4 minerals by treatment with NH_4Cl. The results of his investigation are as follows: Experiments with NH_4 montmorillonite showed that bivalent cations have a stronger exchange ability than univalent cations, with the exception of Rb and Cs. The exchangeability of H ions is similar to that of K ions. Values for the bivalent ions lie near one another. With a hundredfold excess of chloride, 92.6 to 96.0% of the total base is exchanged. NH_4 kaolin has the same exchange properties as NH_4 montmorillonite, except that the linkage of the NH_4 ions is stronger. With a hundredfold excess of chloride, only 73.9 to 80% of the total base is exchanged. The adsorptive capacity of the kaolin is not increased through grinding; this is contradictory to previous experiments of Kelley and Jenny (*Ceram. Abs.*, **19** [5] 124–25 (1940)). NH_4 muscovite and NH_4 biotite showed extramicellar and intramicellar exchange. H and K ions showed the strongest exchange. With a hundredfold excess of chloride, Na exchanged more strongly than all the bivalent cations, and Li exchanged more strongly than Mg and Ca. The exchange of the univalent and bivalent cations at this concentration was 48 to 99% of the total exchange. The different behavior, as compared with that of montmorillonite, is caused by a blockade due to the small diameter of intramicellar spaces in mica. The behavior of feldspar was similar to that of mica, but the exchange of Li and Na was more complete. Exchange experiments with NH_4 permutite showed that the results cannot be applied to clay minerals. Results obtained with potassium minerals to which chlorides of the alkalis and of alkaline earths were added were similar to those found with the corresponding NH_4 minerals. After three months equilibrium was not attained; this is further proof that in mica the exchange is partly intramicellar. When montmorillonite and kaolin were washed with NH_4 acetate and Ca acetate, the adsorption of Ca at pH 5 was 6 to 12% less than at pH 7, and that of NH_4 was only 2 to 3% less than at pH 7. The same tests made with muscovite and biotite showed much greater differences. The decrease in adsorption with muscovite was about 32% for Ba, 37% for NH_4, 92% for Ca, and 97% for Mg. The dependence of the adsorption on the pH of the acetate solution rests to a small extent upon the formation and decomposition of secondary electric double layers and to a greater extent upon the exchange of, e.g., K ions (mica) for H ions. With H minerals, the linkage of H ions increases in strength in the following order: H kaolin $\leqq$ H montmorillonite < H muscovite. The pH determination of these three minerals, made in aqueous suspensions (H mineral corresponding to 1 m.e. H + 30 cc. H_2O), gave the values 3.09, 3.22, and 4.31, respectively. The equilibrium between the adsorbed ions of the clay minerals and the reacting ions was a "true" equilibrium only when the properties of the two ions in equilibrium (valence, diameter of ion) were similar, e.g., Mg and Ca. In all other cases the equilibrium was merely apparent. Differences in equilibria were greatest when the H ion was one of the two cations in the investigated system or when the valences of the adsorbed and the reacting cations were different. Similar results were obtained from tests on the influence of volume on the equilibria. The more similar the properties of the two ions, the less was the equilibrium influenced by the volume of liquid. The explanation for this is that not the concentration of ions but the activities must be taken into account with experiments on equilibria. Mica, when treated with a combined solution of Ca acetate and NH_4 acetate, showed a selective adsorption for NH_4; Ca and NH_4 were adsorbed in the ratio of 6:94. This result was worked out to a method for determining the part of mica and montmorillonite or kaolin in the adsorption of the soil. Among eight soils tested, 30% (13 to 47%) of the total adsorption was due to mica, and 70% (53 to 87%) was due to montmorillonite. The calculation of the adsorptive capacity of montmorillonite showed 100 m.e. for montmorillonite and 40 m.e. for mica per 100 gm. mineral $<2\mu$. The montmorillonite and mica contents of a soil $<2\mu$ can be found by destroying the organic matter with H_2O_2 and determining the proportion in adsorption of the minerals as a basis for their adsorptive capacity. Experiments on exchange in humic acid with Ba acetate and Ca acetate showed that the adsorption of the cation depends considerably on the pH of the acetate solution. The adsorptive capacity for Ba and Ca at pH 5 was only 78% and 74%, respectively, of that at pH 7. With an acetate solution of pH 7, the adsorption of Ca was only 84% of that of Ba. From a mixed solution of equivalent quantities of Ca acetate and NH_4 acetate, humic acid and brown coal from Kassel adsorbed Ca and NH_4 in the ratio of 92:8. The adsorptive capacity of organic matter in soil (determined by means of H_2O_2) was 140 to 270 m.e. per 100 gm. organic matter in eight soils tested. The degree of adsorptive capacity was related neither to the state of decomposition of the organic matter nor to the colloid content of the soil. The organic matter of soils adsorbed the two cations from a mixed solution of Ca acetate and NH_4 acetate in the same ratio as did humic acid and brown coal from Kassel. The adsorption of Ca and NH_4 by soil containing humus was calculated additively from the H_2O_2 soils and the humus content of the original soils, thus proving that inorganic and organic colloids do not measurably affect each other's adsorptive capacities. The nutritive materials are not uniformly distributed or bound. Ca ions are bound predominantly by humus and K ions, and NH_4 ions are bound by mica. Montmorillonite binds both cations equally firmly. This fact shows the great importance of clay minerals and of humus for plants. Adhesive strength and availability of plant food depend largely upon the composition of inorganic and organic soil colloids. F.E.S.

Alsifilm, a mica substitute. F. G. NICHOLLS. *Chem. Eng. & Mining Rev.*, **32** [384] 438 (1940).—In manufacturing Alsifilm, raw bentonite is dispersed in water, and the coarse particles are removed either by centrifuging or by settling. The remaining colloidal material is concentrated to a thick paste by evaporation or centrifuging. The paste is spread over a flat surface and struck off to an even thickness by passage under a knife. Films up to 0.005 in. may be dried in 5 min. by the use of incandescent lamps with

infrared reflectors. Sheets are available in 3-ft. lengths and in widths of 18 in. or more. A Wyoming bentonite appeared to be the most suitable for this process, although clays containing over 75% colloidal material and possessing rapid dispersion properties may be used. For some uses, the thin sheets are cemented together with shellac and compressed under heat. B.C.R.

Alterations in crystal structure of clay minerals as a result of phosphate fixation. P. R. STOUT. *Soil Sci. Soc. Amer., Proc.*, **4**, 177–82 (1939).—Samples of kaolinite and halloysite (ground) fixed 300 to 400 millimoles of phosphate per 100 gm. of the air-dry material. Similar experiments with a bentonite of approximately the same base-exchange capacity as the ground kaolinite and halloysite fixed a relatively insignificant amount of phosphate. Measurements of the loss of water from the system kaolinite plus potassium acid phosphate accounted for the exchange of phosphate ions for hydroxyl ions of the crystal lattice of kaolinite. Kaolinite has a sheet of hydroxyl ions at one side of the basal exchange plane and a sheet of oxygen ions on the other, while bentonite is composed of mica or pyrophyllite-like layers and has a sheet of oxygen ions on both sides of the basal exchange side. S. suggests, therefore, that the relative abilities of the kaolinite and bentonite to fix phosphate are related to the hydroxyl ions available for exchange with phosphate ions. Ground kaolinite of less than one micron effective diameter when phosphated was found to be amorphous to X rays. Removal of the phosphate by leaching with alkaline solutions at pH 9, followed by washing with dilute HCl of pH 3 to 4, restored the X-ray pattern of kaolinite. Distinct X-ray patterns were obtained from the phosphated halloysite. Seventeen lines appeared on the film. When phosphate was removed from the phosphated halloysite by leaching with alkaline solutions, the resulting dephosphated halloysite was amorphous to X rays. Leaching of the dephosphated halloysite with dilute HCl gave a crystalline material identical with that of metahalloysite. X-ray data suggest that the phenomenon of phosphate fixation by ground kaolinite and halloysite is thus a reversible ionic exchange between phosphate ions and component hydroxyl ions of the crystal lattice. A holohedral rather than a hemihedral monoclinic crystal postulated for halloysite explains the interplane spacing of 16.1 a.u. obtained on phosphating halloysite. R.K.

Application of geology to ore finding: I. H. E. EDWARDS. *Chem. Eng. & Mining Rev.*, **32** [384] 440 (1940).—Contouring, the most rapid and informative method of studying an ore body, requires the following information: level and sill floor plans, transverse sections of ore body, longitudinal sections, and assay plans and sections of levels and stopes. Means of preparing structure and assay contours are discussed and illustrated. B.C.R.

Barium. L. SANDERSON. *Can. Mining Jour.*, **61** [10] 658–59 (1940).—Barium is obtained from barytes and witherite. Barytes is obtained mainly from Germany and the U. S. The war may stimulate production in Great Britain. Witherite is exclusively a British product. Both minerals must be carefully mined and dressed. Barium is important principally as an alloy metal. Barium carbonate in glass gives higher refractive index and greater brilliancy, elasticity, and toughness. It is a good flux in enamels. G.M.H.

Bentonite clay and its uses. ANON. *Engineering*, **147**, 679 (1939).—Bentonite, a weathered volcanic ash occurring in the upper Missouri valley, may be either a colloidal or a highly swelling ore. Those similar to plastic clays in swelling properties are called sub-bentonites; they are used largely in the mining industry, where they are compounded in the mud fluid pumped down the drill pipe. The highly colloidal type is used for rejuvenating foundry sands, for stopping seepage of water through and under dams, for rendering sand beds less impervious, etc. Bentonite may be made into a film and substituted for mica (see "Alsifilm"..., this issue). In the German bentonite deposits, calcium occurs as the interchangeable base, and synthetic methods have been tried to substitute Na for Ca. The highly swelling type occurs also in Italy. B.C.R.

Ceramic investigation of a clay from Uitenhage, C. P. V. L. BOSAZZA. *Minerals Research Lab. S. Africa Bull.*, No. 5, pp. 15–18 (1940).—An impure kaolin from Uitenhage, Cape Province, was investigated chemically, petrographically, and by detailed size analysis. The clay is compared with a standard English potting sample supplied by Messrs. Wengers, Ltd., Stoke-on-Trent. Although not stated in the paper, it may be noted that the kaolin occurs adjacent to a massive pure hematite, and therefore the low iron oxide content is remarkable. Most South African kaolins are derived by weathering *in situ* from argillaceous rocks and seldom from granites; this deposit, however, is unique in its close association with a pure iron ore. V.L.B.

Characteristics of the white clays at Grahamstown with special reference to porcelain manufacture. V. L. BOSAZZA. *Minerals Research Lab. S. Africa Bull.*, No. 5, pp. 5–12 (1940).—The clays at Grahamstown, Cape Province, were the first clays examined scientifically in the Union of South Africa; they have acquired a reputation for quality. Later investigations, both on the deposits and on the clays themselves, have shown that the earlier reports overrated the quality and the quantity. B. gives chemical and physical analyses of the kaolins and compares them with other china clays. The Grahamstown kaolins are all of the high-silica type, i.e., over 60 or 70% SiO_2. B. also queries the accuracy of earlier analyses showing iron oxide contents of less than 0.1%. With the exception of the chemical composition, the data of various investigators on kaolins are not strictly comparable. More work should be done on size analysis and mineral identification and particularly on the shape of the particles. Another important difference noted in comparing South African kaolins with English, American, and Japanese specimens is the dispersibility. Many of the local kaolins cannot be dispersed at all due to the coarsely crystalline character of the kaolinite. V.L.B.

Chemistry of clay and brick. J. A. HEDVALL. *Tegel*, pp. 185–88 (1939); No. 1, pp. 13–14, 17–18, 20–24 (1940); abstracted in *Chem. Zentr.*, **1940, I**, 3310.—H. gives an easily understandable presentation of the crystal structure, surface activity, and reactivity of solids for silicate chemistry and the treatment of clays (drying and firing of clays and changes in admixtures in clays on firing). M.V.C.

Chromite deposits in Ratnagiri District and Savantvadi State, Bombay Presidency. L. A. N. IYER. *Records Geol. Survey India*, **74** [3] 372–85 (1939).—A survey of the occurrence of chromite and other minerals in two deposits in the Bombay Presidency is presented. Both deposits are accessible to ports, and the reserves in the two localities are estimated at about 67,000 tons of ore with 30 to 39% Cr_2O_3 and 25% Fe_2O_3. The chromite is associated with serpentine in the form of irregular veins or lenses. The ore contains a considerable amount of chlorite as matrix to the chromite grains. The deposits are partly magmatic and partly hydrothermal in origin. See *Ceram. Abs.*, **17** [10] 341 (1938). A.P.S.

Clay-mineral structures and their physical significance. R. K. SCHOFIELD. *Trans. Brit. Ceram. Soc.*, **39** [5] 147–61 (1940).—S. shows how the atomic structure of the clay minerals as revealed by X-ray analysis accounts for the presence of positively and negatively charged zones on the crystals. Measurements of ionic retention enable these charges to be measured and their variations with pH to be studied. In the presence of sufficiently concentrated salt solutions, cations and anions are retained in equivalent amounts. Firmness of binding varies widely among both cations and anions. Support is found for the view that a network tends to form in clay suspensions through attraction between the positive and negative zones of neighboring crystals. A condition in which the cations and anions leave equal amounts of positive and negative charge "uncovered" is particularly favorable for the formation of a network. See "Physical...," *Ceram. Abs.*, **18** [1] 34 (1939). R.A.H.

Concentration of feldspathic waste from a titanium mine near Roseland, Virginia. D. I. SMITH, R. G. O'MEARA, AND T. N. MCVAY. *Jour. Amer. Ceram. Soc.*, **23** [11] 339–41 (1940).—4 tables, 1 reference.

Degree of dispersion of clays: III, Two-layer method as applied to the Sharples supercentrifuge. E. P. WHITESIDE AND C. E. MARSHALL. *Soil Sci. Soc. Amer., Proc.*, **4**, 100–103 (1939).—A method suited to the quantitative fractionation of clays in the range 100 to 10 mμ is described. Glycerol-water mixtures were used in forming the layers. The method is compared with those using other centrifuges. The tube centrifuge gave results similar to those obtained with the pipette method. Clays saturated with Li, Na, and K were used. R.K.

Deposits of radioactive cerite near Jamestown, Colorado. EDWIN H. GODDARD AND JEWELL J. GLASS. *Amer. Mineralogist*, **25** [6] 381–404 (1940).—Cerite, a rare silicate of the cerium metals, occurs in small deposits in the pre-Cambrian rocks of the Front Range near Jamestown, Colo. They are near the north border of a stock of Silver Plume granite, to which they are genetically related. Numerous lenticular schist masses in the granite suggest proximity of the roof. The cerite rock containing about 75% of cerite occurs as irregular lenses $^1/_4$ to 15 in. wide in narrow aplite-pegmatite zones along the borders of small schist areas. Narrow veinlets of black allanite border the cerite rock, and minute grains of uraninite (pitchblende) and pyrite are present locally. Microscopic examination of the cerite rock shows it to be finely intergrown with varying amounts of allanite, brown epidote, tornebohmite, fluorite, bastnasite, monazite, uraninite, and quartz. An analysis of the purer cerite rock shows 56% rare-earth oxides. A gray variety consisting chiefly of cerite, fluorite, and a brown epidote was found to show mild radioactivity on a photographic plate. An analysis of this material showed 0.513% U_3O_8, 0.20% ThO_2, and 0.07% PbO and gave an age determination of 940,000,000 years. F.J.Z.

Determination of exchangeable bases by the Lundegårdh spectrographic method. V. R. ELLIS AND C. E. MARSHALL. *Soil Sci. Soc. Amer., Proc.*, **4**, 131–35 (1939).—The Lundegårdh method is described, and various methods of evaluating concentrations of cations from the line intensities are compared. Either the reciprocal (L/H) or the difference ($L-H$) of the line transparencies may be used to compare the unknown concentrations with standards. For calcium, the L/H method is preferable. An approximate visual method using a comparator plate gives results accurate to within 10% of the highest concentration used. R.K.

Dispersion of soils for mechanical analysis. JOGENDRA NATH CHAKRABORTY. *Indian Jour. Agr. Sci.*, **8**, 829–37 (1938).—A modification of C.'s method ("Mechanical...," *Ceram. Abs.*, **16** [10] 310 (1937)) avoiding the use of HCl is presented. The results of tests on a number of soils for clay and clay plus silt by this method were comparable to results obtained with the International-A method. A slightly different procedure is suggested for soils containing calcium carbonate. A.P.S.

Electrodialysis of soils. M. PUFFELES. *Analyst*, **65** [774] 501 (1940).—In testing the applicability of Basu's electrodialysis apparatus, P. obtained satisfactory results with soils poor in lime but not with artificially prepared highly calcareous soils which gave no end point. Kissink's method was also used, in which the soil is leached twice with *N* NaCl solution and the calcium in each extract is determined; the difference between the results is regarded as exchangeable calcium. B.C.R.

Enterprise in Travancore State—large-scale production of china clay. S. DOGAR SINGH. *Indian Textile Jour.*, **50**, 244–46 (1940); *Chem. Abs.*, **34**, 6423 (1940).—The washing and refining plant includes levigation and flotation.

Fluorspar ores of Madoc, Ont. C. L. EMERY. *Can. Mining Jour.*, **61** [10] 667–68 (1940).—Fluorspar deposits of post-Ordovician age occupy fault fissures in two fault systems on the pre-Cambrian border in southeastern Ontario. The ore bodies occur both in pre-Cambrian and Paleozoic rocks. Faulting has been extensive. Fluorspar was deposited at intervals during the period of fracturing. The earliest deposits are the purest. G.M.H.

Influence of grinding soil minerals to near molecular size on their solubility and base-exchange properties. M. L. JACKSON AND E. TRUOG. *Soil Sci. Soc. Amer., Proc.*, **4**, 136–43 (1939).—A study was made of the influence of extremely fine subdivision on the solubility and base-exchange properties of microcline, talc, kaolinite, quartz, base-exchange minerals from bentonite, nontronite, and a variety of soil colloids. Subdivision was carried out by grinding for 2 to 14 days in a special ball mill, the bowl of which was made of hardened tool steel and the balls of which were of chrome steel. A rubber-lined mill supplied with agate balls was used to obtain comparative results. Wet grinding was also employed. Practically all of the crystal-lattice bases of the silicates were made exchangeable or soluble in ammonium acetate solution by fine grinding in the steel mill, and a relatively high base-exchange capacity resulted in each case. The silica and alumina of the silicates became relatively soluble in very dilute acids, dilute Na_2CO_3 solution, and neutral salt solutions; hence, the exchange capacity developed by grinding was extremely unstable compared with that of the highly resistant natural base-exchange minerals of the clays. The authors suggest that the increased solubility caused by grinding is due to the disruption of the more stable valence-bond relationships in the silicates; consequently, the increase in specific surface, as the particle size is greatly reduced, must be regarded as a change in kind of surface rather than simple increase in extent of surface. R.K.

Ionic size in relation to fixation of cations by colloidal clay. J. B. PAGE AND L. D. BAUER. *Soil Sci. Soc. Amer., Proc.*, **4**, 150–55 (1939).—A mechanism to explain the fixation of potassium, caused by drying, is proposed in which the size of the ion and the contraction of the variable lattice of the montmorillonitic clay minerals are shown to be the important contributing factors. Experiments were performed on a bentonite colloid and the colloid from the Miami silt loam. Data show that the bentonite colloid does not fix potassium as readily as the Miami colloid and that fixed potassium is slightly affected by concentration of the replacing ion. Large cations, when between the sheets, can prevent the sheets from coming together and fixing potassium. Univalent and divalent cations were tested, and it was found that the ionic sizes close to the size of certain free spaces within the lattice were closely correlated with susceptibility to fixation. R.K.

Kaolin deposits near Bagheshapura, Arsikere Taluk, Hassan district, Mysore. S. L. RAO. *Records Mysore Geol. Dept.*, **37**, 59–60 (1939).—The deposits occur below laterite cappings over gneiss and pegmatites. About 9000 tons of kaolin are available together with 35,000 tons of light-colored clays. See "Mysore's...," *Ceram. Abs.*, **19** [5] 124 (1940). A.P.S.

Kaolin deposits of Koppa-Tirthalli areas. S. L. RAO. *Records Mysore Geol. Dept.*, **37**, 43–55 (1939).—The deposits occur in kaolinized gneiss and pegmatite; they are of variable quality and total only 18,000 tons. A.P.S.

Knowledge of fuller's earths. JACQUES DE LAPPARENT. *Rev. Chim. Ind.* [Paris], **46**, 162–68 (1937); abstracted in *Chem. Zentr.*, **1937, II**, 2504.—The chemical and crystallographic relationships between mica, chlorite, pyrophyllite, talc, and the clay minerals kaolinite, anauxite, and montmorillonite are discussed. The most important constituents of fuller's earths are the clay minerals; kaolinite and montmorillonite seldom possess bleaching properties. Montmorillonite and anauxite can be activated, but kaolinite cannot. Generally speaking, only materials in which the OH ions are directly combined with Si and which contain the grouping $Si_3H_4O_{10}$ can be activated. M.V.C.

Leucite rocks of the active volcano Batoe Tara (Malay Archipelago). H. A. BROUWER. *Proc. Acad. Sci. Amsterdam*, **42** [1] 23–29 (1939).—The rocks can be divided into three groups: (1) lavas: leucite-basanites (partly transitions to leucite basalts, leucitites, and leucite-tephrites); (2) dykes: leucite-basanites; and (3) young

biotite-leucite-tephrites. A brief description of the various rock types and their chemical analyses are given. W.L.

Magnesia from Canadian brucite. M. F. GOUDGE. *Trans. Can. Inst. Mining & Met.*, **43**, 481–505 (1940).—G. deals largely with technology. See *Ceram. Abs.*, **19** [11] 267–68 (1940). G.M.H.

Mechanism of the dehydration of zeolites. W. O. MILLIGAN AND HARRY B. WEISER. *Jour. Phys. Chem.*, **41**, 1029–40 (1937); *Chem. Abs.*, **32**, 852 (1938).—Since the authors found that the H_2O in $CaSO_4 \cdot 0.5H_2O$ is not lost in a zeolitic manner (*Jour. Amer. Chem. Soc.*, **59**, 1456–58 (1937)), as usually stated, a study was made of the mechanism of the dehydration of several minerals designated as zeolites; the methods of X-ray diffraction analysis and isobaric dehydration were used. Special precautions were taken to obtain equilibrium conditions at each temperature at 23.6 mm. aqueous vapor tension. Scolecite was found to be a definite trihydrate that gives a definite dihydrate on isobaric dehydration. Natrolite is a dihydrate, giving a monohydrate upon dehydration. Mesolite is not a definite hydrate but a mixture or a solid solution of scolecite and natrolite. Stilbite, heulandite, thomsonite, analcite, and chabazite are not hydrates; the H_2O is bound by adsorption forces within channels in the lattice. Stilbite and heulandite exist in more than one modification. It was confirmed that some zeolites show a significant lattice shrinkage after prolonged or excessive dehydration. Since some zeolites are definite hydrates and some are not, there is nothing to be gained by using the expression "zeolitic water." See *Ceram. Abs.*, **15** [10] 293 (1936).

Mineral composition and texture of the clay substance of natural molding sands. R. E. GRIM AND C. S. SCHUBERT. *Trans. Amer. Foundrymen's Assn.*, **47** [4] 935–53 (1939).—Samples of eight molding sands were tested, 6 commercial sands and two potential Illinois molding sands. The size-grade distribution of the clay substance was determined, the minerals making up the clay substance of each sand were identified, and the distribution of the important mineral constituents with respect to particle size was determined. Curves of the frequency distribution of the various samples are included. H.E.S.

Mineral Industries Conference, November, 1940. ANON. *Bull. Amer. Ceram. Soc.*, **19** [11] 457–58 (1940).

Mineral phosphates. ALBERT E. WILLIAMS. *Chem. Eng. & Mining Rev.*, **32** [382] 373 (1940).—Deposits of amblygonite, monazite, pyromorphite, and vivianite in the Northern Territory, Australia, are described. B.C.R.

Mineral resources of the Central Provinces and Berar. M. S. KRISHNAN. *Records Geol. Survey India*, **74** [3] 386–429 (1939).—The following minerals mined at present are described briefly: coal, limestone, manganese ore, clay, bauxite, ocher, steatite, iron ore, fuller's earth, laterite, and graphite. Occurrences of asbestos, barytes, corundum, sillimanite, wolframite, soda salts, quartzite, copper ore, marble, lead ore, gold, and lignite have been reported. A.P.S.

Mineralogical and chemical composition of the syenite-granite from Boekit Batoe near Palembang, Sumatra, Netherlands East Indies. W. VAN TONGEREN. *Proc. Acad. Sci. Amsterdam*, **39** [5] 670–73 (1936).—T. gives a petrographical description and chemical analyses of the rocks, which consist mainly of fossil-bearing clay stones. The highest part of the hills is formed by syenite, which merges into quartz-syenite and granitic rocks in places. W.L.

Mineralogical subdivision of fine clay by heavy-liquid specific-gravity separations. D. M. BATSON AND E. TRUOG. *Soil Sci. Soc. Amer., Proc.*, **4**, 104–105 (1939).—Better and more stable dispersions of fine clay in tetrabromoethane-nitrobenzene mixtures were obtained when the clay was saturated with manganese and washed with methanol than when it was saturated with other cations and washed with acetone. A procedure of heavy-liquid specific-gravity separations involving these features gave fairly satisfactory results when applied to a synthetic clay of known mineral composition. See *Ceram. Abs.*, **19** [1] 27 (1940). R.K.

Nepheline-syenite in Korea: I, Dissolution tests of alumina and alkali by treatment with acid solutions. SHOICHIRO NAGAI, AKIRA NARUSE, ICHIRO MORIMOTO, AND TAKEO YAMABE. *Jour. Soc. Chem. Ind. Japan*, **43** [5] 362–66 (1940); Supp. Binding, p. 155B.—A large deposit of nepheline and nepheline-syenite was recently discovered at several places in Korea. Powdered samples of various grades were studied by treatment with solutions of hydrochloric, nitric, or sulfuric acid under various conditions. Alumina was dissolved with an extraction efficiency of about 90 to 95%; alkalis were more easily extracted. M.T.

Nepheline-syenite—review of the literature. GEORGE A. BOLE. *Ceram. Age*, **34** [5] 135–37 (1939).—B. briefly reviews the sources and uses of nepheline-syenite. 22 references. F.G.H.

New calcite source discovered. ANON. *Bull. Amer. Ceram. Soc.*, **19** [10] 415 (1940).

Petrographic study of bonding clays and of the clay substance of molding sands. R. E. GRIM. *Trans. Amer. Foundrymen's Assn.*, **47** [4] 895–908 (1939).—G. briefly outlines modern methods for the study of clay materials including chemical, dehydration, microscopic, and X-ray methods. The prevailing concept of the composition of clays and the application of modern clay researches to studies of natural molding sands and bonding clays are given. A bibliography is included. H.E.S.

Philippine chromite. V. G. LAVA AND I. OLAYAO. *Philippine Jour. Sci.*, **69** [2] 197 (1939).—The chromite deposit located in the Masinloc district, Zambales Province, Philippine Islands, is estimated to consist of at least 8 million tons. Crude and concentrated ores from this deposit have the following chemical composition:

	Crude ore	Concentrated ore
SiO_2	5.6	1.8
Fe_2O_3	17.9	18.5
Al_2O_3 (by difference)	26.2	25.9
Cr_2O_3	33.5	37.6
MgO	16.8	16.2
CaO, TiO_2, V_2O_3	Trace	Trace

The ore is closely associated with peridotite or pyroxenite intrusions and occurs in lenticular masses of varying size, apparently accumulated near the border of peridotite intrusions. Although most of the ore shows a coarse texture, both fine grain and amorphous or massive textures have been observed. The low chromite content has thus far limited the use of this ore to refractory purposes. See *Ceram. Abs.*, **19** [8] 198 (1940). B.C.R.

Potash industry in the United States. J. J. BOURQUIN. *Mining Congr. Jour.*, **23** [1] 57–59 (1937); *Chem. Abs.*, **31**, 8127 (1937).—A historical review and a survey of the future of the industry are given.

Properties and applications of witherite. ANON. *Engineering*, **150** [3896] 208 (1940).—Witherite may be used for manufacturing $BaSO_4$ and softening boiler feed water and as an addition to cement to increase its resistance toward sulfate water. B.C.R.

"Purity" of siliceous materials. V. L. BOSAZZA. *Trans. Brit. Ceram. Soc.*, **39** [7] 206–209 (1940).—After an examination of about 50 specimens of highly siliceous rocks, such as vein quartz, sands, quartzites, sandstones, cherts, flints, and silcretes, B. concludes that (1) high-silica rocks must be analyzed with extraordinary care when used in solubility determinations, since the impurities may be more important than the true silica solubility; (2) the "purity" is often very different from that shown by microscopic examination; and (3) careful spectrographic analyses are essential to confirm the purity of the samples used. R.A.H.

Silica from Dalton, Natal. J. LEVIN. *Minerals Research Lab. S. Africa Bull.*, No. 5, pp. 38–40 (1940).—Samples of a pure form of silica from several places north of Pietermaritzburg, Natal, were investigated. The silica is in the form of a pseudomorph after calcite or gypsum

and occurs in long shallow lenses. The silica is all present as the mineral quartz. The analyses show silica contents from 98 to 99.2%, the main impurity being alumina. The material was found to be unsuitable for glass manufacture, but the possibility of using it as a filler in abrasive soaps was investigated. Since this work was completed, the use of the rock as a filler in the South African paint and rubber industry has also been considered. The silica filler in abrasive soaps is of a very fine-grained character; it has been found to contain colloidal quartz, i.e., particles less than 0.5 μ, in large quantities. The extremely fine-grained character of the German abrasive material formerly supplied to South African soap manufacturers is probably of more importance than the chemical composition. V.L.B.

Staining of feldspathoids and the zonal structure of nepheline. S. J. SHAND. *Amer. Mineralogist*, **24** [8] 508–13 (1939).—The most useful reagent for etching and staining the soda feldspathoids is syrupy phosphoric acid and methylene-blue solution. S. recommends the use of glue and a cover slip for preserving a stained sample. Unless the rock is perfectly fresh, it is unsafe to draw conclusions about the nature of a scanty interstitial material which takes the stain. S. used this method to show that albite, rather than anorthite or kaliophilite, causes the zoning in nepheline crystals. F.J.Z.

Testing bonding clay. N. J. DUNBECK. *Foundry*, **67** [12] 30, 104, 106, 109 (1939).—Details are given for the testing of bonding clays used in foundry practice. F.G.H.

Treatment of bentonite with acid and alkali solutions: I, Acid and alkali treatments of bentonite and acid clay. MUNEYOSI UTIDA. *Jour. Soc. Chem. Ind. Japan*, **42** [5] 299–303 (1939); Supp. Binding, p. 169B.—Bentonite and acid clay (fuller's earth) have many points in common. The samples tested were two swelling-type bentonites and two acid clays. The results of experiments to determine the solubility or insolubility of bentonite in 1 to 10 *N* alkali solutions agreed substantially with those of experiments on acid clay. K. Yamamoto's conclusion ("Physicochemical . . .," *Ceram. Abs.*, **14** [8] 199 (1935); *Jour. Soc. Chem. Ind. Japan*, **41**, 251 (1938)), which involved the solubility of Japanese acid clay in alkali solutions, can essentially be applied to bentonite; the clay mineral of both Japanese acid clay and bentonite is usually montmorillonite. **II, Alternate treatment with acid and alkali solutions.** *Ibid.*, **42** [5] 303–305 (1939); Supp. Binding, p. 169B.—U. determined the solubility of purified bentonite from Yamagata Prefecture by alternate treatment with 6 *N* HCl and 1 *N* NaOH solutions. The sample clay consists of montmorillonite (not of beidellite) and contains no soluble free silica. According to the method of C. E. Marshall ("Chemical. . . ," *Ceram. Abs.*, **16** [11] 352 (1937)) the sample clay has the skeleton formula $Si_{8.00}O_{19}\cdot Al_{3.18}Fe_{0.18}Ca_{0.04}Mg_{0.28}O_{10}$. The solubility of bentonite in an acid or alkali solution is irrespective of the degree of swelling of the clay and is proportional to the number of cycles of treatments. The solution of bentonite particles proceeds gradually from a surface layer to an inner layer. The insoluble particles left after the treatment with acid are the excess of silica, and those left after the treatment with alkali are the excess of alumina (and bases). The excessive amount of silica and alumina seems to increase with increase in acid and alkali concentration. **III, Properties of treated substances.** *Jour. Soc. Chem. Ind. Japan*, **42** [5] 305–308 (1939); Supp. Binding, pp. 169–70B.—One Japanese acid clay and two swelling-type bentonites were treated with hot 1 *N* NaOH and then with hot dilute HCl solution and were finally electrolytically dialyzed. The empirical formula, base-exchange capacity, moisture adsorption capacity, and thermal dehydration curves of the clay thus treated are given. U. concludes that most swelling-type bentonites and Japanese acid clays are composed chiefly of montmorillonite with admixed soluble silica. See "Yamagata . . .," *Ceram. Abs.*, **19** [5] 127 (1940). M.T.

Use of molding sand and its correct composition. F. PASCHKE. *Giessereipraxis*, **61** [7] 83–89 (1940).—P. emphasizes the necessity of knowing the properties of molding sands and the principles for mixing different sands to obtain satisfactory, sound castings and discusses the various properties, particularly grain size, grain shape, and distribution of the grains in the sand. Synthetic molding sands (usually mixtures of different sands) are also discussed. Recently the Geko process has found a fairly wide application; it consists of a purely inorganic preparation and is used as a binder for even binder-free sands, as Geko forms gels which swell in water. This material (1%), added to a synthetic sand of pure quartz and small clay content, gives an excellent molding sand of absolute uniformity. Data show the required amount of fresh molding sand to be added daily to old molding sand. M.H.

Use of sodium metaphosphate for dispersion of soils for mechanical analysis. E. H. TYNER. *Soil Sci. Soc. Amer., Proc.*, **4**, 106–13 (1939).—T. investigated the effectiveness of sodium metaphosphate as a dispersing agent. Experiments show that 50 cc. of 0.1 *N* sodium metaphosphate solution and overnight shaking are adequate for the ultimate dispersion of the clay fractions less than 2 μ. The effectiveness of sodium metaphosphate depends upon the absorption of the sodium ions with the replacement of calcium ions. The calcium is then tied up as a sodium calcium metaphosphate anionic complex. The stability of suspensions is unaffected by aging up to six days. The preparation and the properties of sodium metaphosphate solutions are discussed. R.K.

Utilization of Philippine low-grade chromite. V. G. LAVA. *Philippine Jour. Sci.*, **71** [2] 133 (1940).—Intensive concentration experiments with tabling, froth flotation, and electromagnetic methods showed conclusively that the Cr_2O_3 content could not be increased above 39% because of the fairly homogeneous nature of the ore. See *Ceram. Abs.*, **19** [8] 198 (1940). B.C.R.

Variable structures and continuous scattering of X-rays from layer silicate lattices. STERLING B. HENDRICKS. *Phys. Rev.*, **57** [5] 448–54 (1940).—Crystals of some micas and related compounds having layer lattices show pronounced continuous scattering of X rays together with normal interference maxima. Continuous scattering is explained as arising from the destruction of the lattice periodicity normal to the perfect cleavage of these types of substance. This is a result of the translation of some layers along the *b* axis and parallel to the cleavage by $nb_0/3$, where b_0 is the unique lattice periodicity and *n* is an integer. Various crystals differ in their degree of randomness, and four general types are recognized: (1) crystals having no irregularity, (2) most elements of the crystal mosaic having a few irregular layers, (3) some elements having a regular sequence of layers and others having many irregular layers, and (4) all elements having many irregular layers which leads to a small pseudo unit of structure. 7 photographs, 1 sketch. J.L.G.

SEPARATE PUBLICATIONS

Clays. PAUL M. TYLER AND A. LINN. Preprint from U. S. Bur. Mines Minerals Yearbook, 1940. Govt. Printing Office, Washington, D.C. 17 pp. Price 5¢. R.A.H.

Mineral Resources of the Union of South Africa. Dept. of Mines, Union of South Africa. 544 pp., illustrated. Price 5s.—The previous edition of this work was published by the Geological Survey of South Africa in 1936. Since then, the mineral development of the Union has been considerably accelerated. The new edition has been extensively revised and enlarged. The section on nonmetallic minerals is of particular interest to the ceramist. The Transvaal has large and in many cases undeveloped deposits of andalusite, kyanite, sillimanite, zircon, topaz, corundum, clays, etc. With the exception of corundum, andalusite, and chromite, few quantitative data are available on these materials. Chromite is dealt with under the section on base metallic minerals. Reference is made to the chemical composition of the ores and the possibility of concentration of the disseminated types. South African chrome ores are used chiefly for chemical and refractory purposes; the latter use, however, is only briefly discussed. Research is still in progress on the character of

South African chromites. Some of the data on magnesite are inadequate. The South African magnesite deposits have been overrated. With the wartime demand for magnesium, research on the separation of the adhering impurities such as talc, serpentine, etc., is necessary before large-scale exploitation in possible. Although high-grade talc occurs in the Transvaal and Natal, the deposits are usually of a very erratic nature. V.L.B.

Portable Cabinets for Materials Used in Mineral Determinations. KENNETH G. SKINNER. *U. S. Bur. Mines Information Circ.*, No. 7127, 6 pp. Free.—S. describes the construction and equipment of two portable cabinets designed to facilitate field and laboratory work on mineral determinations and gives a list of the kind and amount of materials necessary to construct them. R.A.H.

Quyta Lake and Parts of Fishing Lake and Prosperous Lake Areas, Northwest Territories. A. W. JOLLIFFE. *Can. Dept. Mines, Geol. Survey, Mines & Geol. Branch, Dept. Mines & Resources, Paper*, No. 40-14 (1940). 9 pp. Price, paper, 10¢.—This area is over 500 miles north of the railhead at Waterways, Alberta, but easily accessible. Pegmatites in the southeastern part of the area carry tourmaline, spodumene, and andalusite. In adjoining areas they carry beryl, lazulite, lepidolite, tantalite, and other minerals. J. gives no estimate of their commercial importance. G.M.H.

Talc, Steatite, and Soapstone; Pyrophyllite. HUGH S. SPENCE. *Can. Dept. Mines, Bur. Mines, Dept. Mines & Resources, Pub.*, No. 803 (1940). 139 pp., bibliography and index, 13 plates, 4 figs. Price, paper, 50¢.—Talc production in Canada dates back to 1886. Real development, however, started in 1906 with the production of white, high-grade, foliated talc in the Madoc district of Ontario, where it is still being milled on a large scale. In 1922, production of cut soapstone began in the eastern townships of Quebec. Talc and soapstone have been mined intermittently in other parts of the Dominion. Up to the end of 1938 production totaled 388,515 tons. Over one half of the annual production is exported to the U. S. There is little production in British Columbia. A white steatitic talc is found on the British Columbia-Alberta border. Other talc deposits in the province yield an off-color grade of ground product. Little is known of soapstone deposits in the prairie provinces. Nearly all the Ontario production has been from the Madoc area, although low-grade talc has been mined in small quantities elsewhere. Attempts have been made to produce soapstone blocks for pulp-mill furnace use in the Lake of the Woods area, where there are several deposits. Distance from markets seems to militate against the success of such ventures in that area. Talc and soapstone generally similar to those mined in Vermont are found in Quebec. The Quebec industry is based mainly on the production of cut soapstone furnace brick for kraft pulp mills, ground waste, and dust. Some occurrences are known in the Maritime Provinces. S. describes briefly the principally known Canadian deposits, the industry in Canada and throughout the world, and the mining and preparation of products for the market and discusses the character, etc., of talc, steatite, and soapstone and analyses of Canadian and foreign materials. He also gives general information on pyrophyllite and describes occurrences at Kyuquot Sound, on Vancouver Island, British Columbia, and in the Lake Memphremagog area of Quebec. G.M.H.

PATENTS

Clay processing. G. J. BARKER AND EMIL TRUOG (Wisconsin Alumni Research Foundation). Can. 390,577, Aug. 6, 1940 (April 5, 1939; in U. S. April 6, 1938). G.M.H.

Fluorspar ore concentration. JULIUS B. CLEMMER AND CARL O. ANDERSON (Mahoning Mining Co.). Can. 391,507, Sept. 24, 1940 (July 13, 1939; in U. S. July 20, 1938). G.M.H.

High temperature mica product. WILLIS A. BOUGHTON AND WILLIAM R. MANSFIELD (New England Mica Co.). Can. 390,041, July 16, 1940 (Oct. 18, 1936). G.M.H.

Titaniferous ore beneficiating method. FRANKLIN L. KINGSBURY AND WILLIAM GRAVE (National Lead Co.). Can. 390,845, Aug. 20, 1940 (Dec. 31, 1937). G.M.H.

Treatment of minerals by froth flotation. M. VOGEL-JORGENSEN. Brit. 525,506, Sept. 11, 1940 (Feb. 22, 1939).

Chemistry and Physics

Adsorption at crystal-solution interfaces: IX, Concentration of foreign substances in solution relative to the quantity adsorbed by the host crystal. WESLEY G. FRANCE AND PHOEBE P. DAVIS. *Jour. Phys. Chem.*, **40**, 177–85 (1936); *Chem. Abs.*, **30**, 2823 (1936).—No relation was found between the number of colloidal particles of dye present in solution and the amount of dye adsorbed by a given host crystal. X-ray powder spectrographs of crystals containing adsorbed impurities showed the same lattice constant for impure as for pure crystals. The dichroism observed in crystals containing adsorbed dye is accounted for by the assumption that the dye molecules are oriented with respect to themselves and to the face on which they are adsorbed. The color effects observed under the polarizing microscope in crystals of NH_4 alum and dye No. 13 lead to the view that the dye molecules are adsorbed with their long axes perpendicular to the cube faces of the alum crystal. The data for the adsorption of dye by alum and nitrate crystals failed to fit either the Langmuir or the adsorption-isotherm equation but were reproduced over most of the range by the equation $a = kc^{1/n} - k'c^{-1/n'}$ (1), where a = concentration of foreign material deposited on crystals expressed in moles of foreign material per mole of host crystal and c = number of moles of impurity per mole of crystal in solution. The term $k'c^{-1/n'}$ indicates the occurrence of a counter-adsorption process. Examination of this term shows that adsorption commences not at $c = 0$ but at a value of c such that $kc^{1/n} = k'c^{-1/n'}$ and that $k'c^{-1/n'}$ possesses the value ∞ at $c = 0$ but falls off rapidly to zero at low values of c. Equation 1 predicts that at high values of c an adsorption isotherm would fit the data within the limits of error, but this was not always true because of precipitation of part of the dye at higher concentration. 35 references.

Adsorption of water vapor on silica surfaces by direct weighing. H. M. BARRETT, A. W. BIRNIE, AND M. COHEN. *Jour. Amer. Chem. Soc.*, **62** [10] 2839–44 (1940).—Illustrated. F.G.H.

Alpha, beta transformation of quartz. H. S. ALLEN. *Nature*, **145** [3669] 306–307 (1940).—A. reviews the experimental results of Raman and Nedungadi (*Ceram. Abs.*, **19** [11] 268 (1940)) and suggests that (1) at any transition temperature (including the melting point), some kind of resonance occurs between two approximately equal frequencies characteristic of the phases concerned, and (2) the Sutherland-Lindeman melting point formula may be applied to the transition point. J.L.G.

Calculation of the compositions of phases in equilibrium. GEORGE SCATCHARD. *Jour. Amer. Chem. Soc.*, **62** [9] 2426–29 (1940).—The compositions of two phases of a binary system which are in equilibrium may be conveniently determined by plotting for each phase the activity or the chemical potential of one component against the same property of the other component, with the same standard for each state of aggregation. At equilibrium the two curves intersect. The corresponding compositions may be determined from an auxiliary plot of either activity or chemical potential against composition. The application of this method to several typical systems is outlined. Illustrated. F.G.H.

Ceric sulfate in volumetric analysis. JAMES R. POUND. *Chem. Eng. & Mining Rev.*, **32** [383] 418 (1940).—Ceric sulfate may be used for determining ferrous salts in the presence of acetic, oxalic, tartaric, and citric acids, alcohols,

chlorides, and hydrochloric acid in small concentrations. When used with a catalyst such as iodine or osmic acid, arsenic and tin may also be determined. B.C.R.

Comparative study of methods of joint determination of metallic, ferrous, and ferric iron. Z. E. LUKINA. *Zavodskaya Lab.*, **9**, 19–22 (1940).—The joint determination of metallic, ferrous, and ferric iron in direct reduction products and in ores by both the Kaufmann and the Ingeberg methods is possible. Both are sufficiently accurate, but the latter takes more time. The mercuric bichloride method can be used for the determination of metallic iron. Determinations in basic slag can be made by a combined method; ferric iron can be determined by the Kaufmann method, and metallic and ferrous iron can be determined by the Ingeberg method. P.B. & E.S.

Decomposition of rocks and ceramic materials with a small amount of sodium carbonate. JAMES I. HOFFMAN. *Jour. Research Nat. Bur. Standards*, **25** [3] 379–83 (1940).—In a method for the decomposition of rocks and ceramic materials, only 2 parts of sodium carbonate are used for 1 part of sample. The fusion is made in a 75-ml. platinum dish instead of a crucible. If silica is to be determined, the same dish is used for the fusion, the disintegration of the melt with hydrochloric acid, the evaporation to dryness, and the ignition of the silica. R.A.H.

Detection and elimination of phosphate in qualitative analysis by means of zirconium salts. FRANK K. PITTMAN. *Ind. Eng. Chem., Anal. Ed.*, **12** [9] 514–15 (1940).—A revised method for the detection and elimination of phosphate, based on Curtman's zirconyl chloride method, depends upon the fact that zirconium (with hafnium) forms a phosphate which is insoluble in strongly acid solution; hence, phosphate can be removed effectively from acid solution by the addition of soluble zirconium salts. Semiquantitative data show that the method of detection is sensitive, and the method of elimination is completely reliable from a qualitative standpoint. Experiments are cited which show that nearly all the disadvantages of the present methods have been overcome. F.G.H.

Determination of manganese as manganese ammonium phosphate monohydrate. R. C. CRIPPEN. *Chemist-Analyst*, **29** [3] 54–55 (1940).—After removal of interfering ions, the $MnNH_4PO_4 \cdot H_2O$ is precipitated as in the procedure for determining magnesium, filtered, and washed. After three final washings with 10-ml. portions of ether, the crucibles are wiped and placed in a desiccator for weighing. C. also recommends this method for the determination of phosphorus and arsenic. A.P.

Determination of phosphorus in titanium steels. A. T. ETHERIDGE. *Analyst*, **65** [774] 496 (1940).—In the determination of phosphorus in titanium steels, a greater excess of nitric acid than is usually used is necessary as well as a vigorous stirring of the solution after the addition of the molybdate reagent. In dissolving a 2.0-gm. sample, 45 ml. of nitric acid are used for the solution of the steel, and an excess of 50 ml. more are then added. B.C.R.

Determination of rhenium in molybdenite minerals. C. F. HISKEY AND V. W. MELOCHE. *Ind. Eng. Chem., Anal. Ed.*, **12** [9] 503–506 (1940).—A method for the quantitative determination of 5-μgm. amounts of rhenium in the presence of millionfold excesses of molybdenum combines a modified distillation and modified colorimetric technique. It has been applied to the analysis of 28 molybdenite samples. F.G.H.

Determination of silica. I. M. KORENMAN AND L. A. KOZHUKHIN. *Zavodskaya Lab.*, **9**, 43–45 (1940).—The colorimetric method developed consists in fusing the silicate with a tenfold amount of soda, dissolving the melt in hot water, adding an ammonium molybdate and hydrochloric acid solution to form silicomolybdenic acid and afterward to reduce the latter, and colorimetrically comparing the obtained blue solution with a standard solution treated in the same way. The silicomolybdenic acid forms in an acid medium and only in a definite interval of pH concentration; a small amount of ammonium molybdate (2 ml. of a 10% solution) should be added to the melt obtained. The reducing agent (sodium sulfite) should be added in a definite proportion, a considerable excess being undesirable. The most appropriate intensity of coloring is given by 0.5 to 1.0 mgm. SiO_2 in 20 ml. of the solution; the intensity after an addition of sodium sulfite increases with the time, but this increase is appreciable for only the first 15 min. A twentyfold amount of Ca, Mg, and Al salts has no effect on the formation of silicomolybdenic acid or on the coloring. P.B. & E.S.

Determination of titanium. M. S. NOVAKOVSKIĬ AND D. B. TSIONSKAYA. *Zavodskaya Lab.*, **9**, 103–104 (1940).—The method consists in determining titanium in the presence of iron by titration with sodium bichromate or chloric iron in the presence of indigo carmine. The determination is precise, takes no more than 5 min., and can be recommended for plant laboratories. The possibility of a selective reduction of iron by Bi amalgam is noted. P.B. & E.S.

Differentiation of some silicate melts due to formation of two immiscible fluids. D. P. GRIGOR'EV AND E. V. ISKYUL. *Izvest. Akad. Nauk S.S.S.R., Classe sci. math. nat., Ser. geol.*, **1937**, pp. 77–106.—The silicate melts contained SiO_2 51.0, Al_2O_3 12.0, MgO 13.0, CaF_2 14.0, and K_2CO_3 10.0%. The charge was raised to 1200° to 1250°, held at that temperature for 20 min., and then cooled to room temperature. The melt became divided into two layers. The lower layer was more basic and relatively richer in MgO, CaO, and Al_2O_3, while the upper layer was relatively richer in SiO_2, K_2O, and F. The cause for the immiscibility was found to be F. The results are interpreted to show that there may be immiscibility in silicate magmas. See "Crystallization. . . ," *Ceram. Abs.*, **16** [1] 44 (1937). B.Z.K.

Egyptian blue and refractories for copper-smelting furnaces. B. V. IVANOV, A. I. TSVETKOV, AND I. M. SHUMILO. *Compt. Rend. Acad. Sci. U.R.S.S.*, **20**, 685–87 (1938).—A mineral that proved to be Egyptian blue was found in silica brick in the roof of a copper-smelting furnace, in the transitional zone (between the unaltered and the tridymite zones) subjected to the influence of comparatively low temperatures. The mineral was isolated and subjected to a complete crystallographic, optical, and chemical investigation. Attempts to synthesize this mineral were successful; it is easily produced from metallic copper oxide, carbonate, or acetate by sintering with $CaCO_3$ and SiO_2 according to the formula with an addition of alkali carbonate as a flux. Sintering occurred at 850° after 20 hr. The output was above 50% of the charge by weight. The possibility of manufacturing it on a large scale is emphasized, P.B. & E.S.

Electrodeposition of tin from chloride solutions. F. G. KNY-JONES, A. J. LINDSEY, AND A. C. PENNEY. *Analyst*, **65** [774] 498 (1940).—Good results may be obtained in the deposition of tin from stannic solutions when potential control is exercised and when ammonium salts are absent or, if they are present, when the solution is neutralized just prior to reaching the end point. B.C.R.

Electron-ray titrimeter. EARL J. SERFASS. *Ind. Eng. Chem., Anal. Ed.*, **12** [9] 536–39 (1940).—Two simple thermionic voltmeters which operate from the a.-c. or d.-c. lighting circuit are described. They are particularly suited for potentiometric titrations, since an inexpensive electron-ray tuning indicator tube is used as an indicator instead of the usual microammeter. The unrectified circuit described is particularly convenient for use with polarized electrodes, whereas the rectified circuit may be used for titration systems requiring the use of the calomel cell. Both units may be assembled from ordinary radio replacement parts for less than the cost of a small portable radio receiver. Illustrated. F.G.H.

Glass electrodes. A. H. W. ATEN, LOUISE BOERLAGE, AND J. E. GARSSEN. *Chem. Weekblad*, **37** [12] 158–66 (1940).—The principle of pH measurements by means of glass electrodes and the apparatus used are described. Comparative measurements made with new electrodes from Jena glass and from older kinds of glass show that the former have a smaller inner resistance; the apparatus can be simpler, therefore, than that used with glass electrodes of very high resistance. The authors recommend the use, for pH > 7, of solutions with higher and lower pH

and the interpolation of the correct value. The glass electrode can also be used for electrometric titrations; the method is described in full. M.H.

Hydrated calcium silicates. J. FORET. *Atti X° congr. intern. chim., 1938*, **2**, 638; *Trans. Brit. Ceram. Soc.*, **39** [7] 70A (1940).—X-ray investigations show that the product obtained by heating $CaO + SiO_2 + H_2O$ under pressure up to 130° is identical with the calcium silicate obtained by precipitation at room temperature. Above 140° a β-form capable of absorbing CaO is formed. The degree of hydration of these silicates decreases with increase in temperature of formation.

Influence of transformation processes and of aggresive gases on the reactivity of SiO_2. J. ARVID HEDVALL AND KAJ OLSSON. *Z. Anorg. & Allgem. Chem.*, **243** [3] 237–45 (1940).—The formation of Ca_2SiO_4(700° to 1000°) from a powder mixture was accelerated through conversion processes. Small amounts of fluxing material (Na_2WO_4 and NaCl, 1%) increase the amount of conversion both for the stable phases and during the conversion period. NaCl is more effective. Tridymite reacts more easily than either cristobalite or α-quartz. With Cl_2, CO(at 900°), and H_2(at 1100°), previously treated tridymite shows an increase of the reactivity (900° to 1000°) only in the case of Cl_2. Mixtures of carbon (0.1 to 1%) play no role in the conversion process (900° to 1000°). R.K.

Lead titanate: crystal structure, temperature of formation, and specific gravity data. SANFORD S. COLE AND H. ESPENSCHIED. *Jour. Phys. Chem.*, **41**, 445–51 (1937); *Chem. Abs.*, **31**, 4557 (1937).—The reaction of PbO and TiO_2 to form $PbTiO_3$ begins at 360° and is complete at 375° in 40 hr. Crystals from molten Na_2WO_4 are yellow orthorhombic bipyramids. From powder data the axes *a*, *b*, and *c* are 4.000, 4.211, and 3.875 a.u., *Z* is 1, and calculated density is 7.65, in agreement with the observed density, 7.52. The space group is V_h^1, and the atomic coördinates are the same as those for cubic $CaTiO_3$ (perovskite), with Pb replacing Ca.

Physically disperse materials and their use in mortar-binding materials. B. V. IL'IN. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Tsementov*, No. 15, pp. 7–108 (in German, 109–16) (1935); *Chem. Zentr.*, **1938, II**, 3662; *Chem. Abs.*, **34**, 6149 (1940).—An attempt is made on the basis of laboratory results to formulate scientific principles to meet the technical problem of disperse matter. The work covers the following topics: surface forces; disperse systems; heat of wetting and degree of dispersion; sedimentation of suspensions; hysteresis, plasticity, friction, and hardness of disperse systems; influence of admixtures; surface phenomena in disperse systems; and physical-chemical analyses.

Rapid method for the determination of moisture in clay. E. A. HERTZELL. *Amer. Refrac. Inst. Tech. Bull.*, No. 67, 3 pp. (Feb., 1938).—H. describes a method for the determination of moisture in clays which can be completed in 5 min. The method depends on the chemical reaction between calcium carbide and water; 100 gm. of clay are slowly mixed with an amount of calcium carbide (20 mesh and finer) equal to approximately 2 ½ times the percentage of moisture in the clay. The carbide is slowly added to the clay, and the two substances are rubbed together with a spatula. After all the carbide has been added, the resulting product is weighed. The mixing is then continued for 1 min., and a second weighing is made. The reweighing is continued until two consecutive weighings are of the same magnitude. The calculations are as follows:

$$\% \text{ moisture (wet basis)} = 1.38\,(W + C - F)$$

$$\% \text{ moisture (dry basis)} = \frac{138\,(W + C - F)}{100 - 1.38\,(W + C - F)},$$

where W = weight of wet sample, C = weight of calcium carbide, and F = final weight when reaction is completed. The method has been used as an accurate control method in the refractory industry. H.E.S.

Rapid quantitative method for barium. E. R. HARRINGTON. *Chemist-Analyst*, **29** [3] 52 (1940).—$BaSO_4$ is evaluated by a turbidimetric method, using a midget 15-watt Mazda bulb and a General Electric light meter. Checks with the gravimetric method within 0.3% were obtained. A.P.

Structure of tetracalcium aluminoferrite. W. BÜSSEM. *Fortschr. Mineral., Krist., & Petrog.*, **22**, XXXI (1937); *Neues Jahrb. Mineral. Geol.*, Ref. I, **1938**, 206; *Chem. Abs.*, **33**, 2787 (1939).—$4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ forms a solid solution with $2CaO \cdot Fe_2O_3$. It is orthorhombic, *a* 5.34, *b* 14.44, *c* 5.52 a.u.; space group (probably V_h^{28} (Imma)). It occurs in Portland cement.

Thixotropic behavior and structure of bentonite. E. A. HAUSER AND C. E. REED. *Jour. Phys. Chem.*, **41**, 911 (1937); *Trans. Ceram. Soc.*, **37** [2] 11A (1938).—Natural bentonite was subjected to a centrifugal fractionation procedure which yielded five fractions of varying average equivalent spherical diameter of 14.3 to 87 mμ. The exchange capacity and pH concentration relation of all particle-size fractions of hydrogen bentonite are identical within the limit of experimental error. The specific conductance of hydrogen bentonite suspensions increases with a decrease in average equivalent spherical diameter of the suspended particles but is much less than would be calculated from the hydrogen-ion activity of the same suspensions. Under corresponding conditions of concentration of bentonite and electrolyte and temperature, the smaller the average equivalent spherical diameter of the suspended particles, the shorter is the time required to form a gel of given strength. In suspensions of the finest particles of bentonite, it is possible to detect evidence of gel structure at concentrations of bentonite less than 0.05%. Ultramicroscopic observations indicate that gelation consists in the formation of primary clusters of individual particles followed by secondary aggregation of these clusters into a network intermeshed with channel and patches of free dispersing medium. Discussion of the results indicated that they support the theory of the open porous structure of the bentonite particle and the "equilibrium field of force theory" of gel structure.

X-ray analysis of the structure of synthetic titanium slags. E. BELYAKOVA, A. KOMAR, AND V. MIKHAILOV. *Metallurg*, **15** [4] 3–5 (1940).—Debye diagrams were made of basic, acid, oxidized, and unoxidized synthetic Ti slags. The chief component found was $CaOTiO_2$. Oxidation of the slags did not affect the position and intensity of the lines, despite the fact that the slag was changed from blue to white during oxidation. The results indicate that TiC does not enter into combination with any of the slag components. Free oxides such as TiO_2, Ti_2O_3, and TiO were not found in the slags. B.Z.K.

X-ray studies of dolomite heated at different temperatures in CO_2 atmosphere. S. KOZU, K. TAKANE, AND K. OMORI. *Jour. Japan. Assn. Mineralogists, Petrologists, & Econ. Geologists*, **21** [5] 173–82 (1939).—The authors studied the dissociation phenomena of dolomite by the X-ray powder method. Samples heated at 600°, 800°, and 1000° were compared with calcite and magnesite. When dolomite is heated in a CO_2 atmosphere, two reactions occur: (1) $CaCO_3$ remains as calcite, but $MgCO_3$ dissociates and periclase is formed; $CaCO_3$ dissociates and changes to the cubic crystal of CaO. Y.K.

SEPARATE PUBLICATION

Petrographic Methods and Their Application to the Examination of Nonmetallic Materials. GEORGE T. FAUST AND ALTON GABRIEL. *U. S. Bur. Mines Information Circ.*, No. 7129, 15 pp. Free.—A technique developed for mineral-dressing problems, in which the petrographic microscope is used, is described. R.A.H.

PATENTS

Alkali aluminate extraction. REMO SZYIA OPATOWSKI AND PIERO ADAMOLI (Società Italiana Potassa). Can. 390,057, July 16, 1940 (June 3, 1937). G.M.H.

Electrolytic magnesium production. SAMUEL L. MADORSKY. Can. 391,037, Sept. 3, 1940 (Jan. 23, 1939; in U. S. Jan. 25, 1938). G.M.H.

Magnesium recovery. PHILIPP BALZ (Magnesium Elektron, Ltd.). Can. 392,057, Oct. 22, 1940 (Nov. 27, 1936). G.M.H.

Making cadmium sulfide pigments. J. J. O'BRIEN. (Glidden Co.). U. S. 2,220,117, Nov. 5, 1940 (Jan. 5, 1939).

Making lead zirconium silicate. C. J. KINZIE (Titanium Alloy Mfg. Co.). U. S. 2,215,737, Sept. 24, 1940 (June 12, 1934; Dec. 24, 1937).—The method of making a double silicate of zirconium consists in heating a charge composed of finely milled zirconium silicate and lead oxide at about 800°C. to secure a substantially complete reaction and decomposition of the zirconium silicate to form a normal lead zirconium silicate ($PbZrSiO_5$).

Pigmentary lead titanate. HELMUT ESPENSCHIED (National Lead Co.). Can. 390,844, Aug. 20, 1940 (Dec. 31, 1937). G.M.H.

Pigment and method of making. W. D. STILLWELL (Harshaw Chemical Co.). U. S. 2,215,623, Sept. 24, 1940 (Dec. 31, 1937).—A color composition substantially of the molecular formula $4PbO \cdot Sb_2O_5 \cdot 4TiO_2$.

Pigment titanate. GORDON D. PATTERSON (Canadian Industries, Ltd.). Can. 390,812, Aug. 20, 1940 (Aug. 12, 1938). G.M.H.

Process and means for recovering vanadium and uranium from ores. H. D. BROWN. U. S. 2,217,665, Oct. 15, 1940 (Aug. 22, 1938).

Production of cadmium colors. J. J. O'BRIEN (Glidden Co.). U. S. 2,220,116, Nov. 5, 1940 (Jan. 29, 1938).—In the production of cadmium sulfide pigments the step comprises calcining the pigment in a calcination zone in an atmosphere which is at least partially reducing and produced by the volatilization of a volatile nitrate.

Production of titanium pigments. L. C. ECKELS (E. I. du Pont de Nemours & Co.). U. S. 2,216,879, Oct. 8, 1940 (March 30, 1938).

Sodium chromate production. MARVIN J. UDY. Can. 389,843, July 9, 1940 (Dec. 3, 1937; in U. S. Nov. 30, 1937). G.M.H.

Sodium orthosilicate and method of making. B. K. BEECHER (Michigan Alkali Co.). U. S. 2,219,646, Oct. 29, 1940 (March 18, 1939).—A method of making sodium orthosilicate consists of the steps of mixing caustic soda, silica, and soda ash, the latter being present in an amount in addition to that normally present in the caustic soda, and heating below the fusion point of the caustic soda to cause reaction between the latter and the silica.

Titanium-containing pigment. JULIUS DRUCKER (I. G. Farbenind. A.-G.). Can. 390,598, Aug. 6, 1940 (Feb. 15, 1935). G.M.H.

Titanium oxide pigment and process for producing. J. A. GEDDES (E. I. du Pont de Nemours & Co.). U. S. 2,219,129, Oct. 22, 1940 (Sept. 8, 1938).—A process for producing an improved titanium oxide pigment comprises intimately associating with the pigment subsequent to calcination and while it is in aqueous suspension a relatively small amount of a water-insoluble basic compound of cobalt.

Titanium pigment. GEORG. MEDER (I. G. Farbenind. A.-G.). Can. 390,222, July 23, 1940 (April 15, 1937). G.M.H.

Titanium pigment production. A. M. ERSKINE (E. I. du Pont de Nemours & Co.). U. S. 2,218,704, Oct. 22, 1940 (July 23, 1937).—A process for producing a titanium oxide pigment stable and resistant toward lithographic breakdown comprises precipitating upon the pigment, and subsequent to calcination thereof, about 0.2 to 2% of hydrous titanium oxide and thereafter drying the treated pigment at a temperature not exceeding substantially 200°C.

Treating titanium pigments. W. H. MADSON AND W. H. DAIGER (E. I. du Pont de Nemours & Co.). U. S. 2,216,536, Oct. 1, 1940 (April 21, 1937).— A process for producing a titanium-containing pigment substantially free from grit particles comprises digesting a slurry of a calcined titanium dioxide pigment containing about 0.2% to about 10% of added dilute salt for a period of at least 30 min. at a temperature of about 100°C.

White lead. G. W. THOMPSON AND ALEXANDER STEWART (National Lead Co.). U. S. 2,218,940, Oct. 22, 1940 (March 26, 1937).

White titanium pigment. WILLIS F. WASHBURN, ROY DAHLSTROM, AND ANDREW T. MCCORD (National Lead Co.). Can. 390,846, Aug. 20, 1940 (Dec. 31, 1937). G.M.H.

General

Air-borne matter. H. L. M. LARCOMBE. *Ind. Chemist*, **15** [177] 379–82; [178] 418–21; [179] 440–43 (1939).—The centralization of industrial activity in and around the great cities of the world has resulted in the pollution of the surrounding air by a great variety of air-borne matter. Dust dispersoids or aerosols in the air are generally assumed to originate from (1) combustion and explosion: reduction of solid and liquid fuels to ashes, fumes, and smoke; (2) crushing: disintegration of concrete and asphalt, process dust, milling, pulverized coal, etc.; (3) mechanical dispersion of liquids: spray evaporation, particles of salt in the atmosphere of seaboard districts; (4) condensation of gases and vapors: formation of rain from water vapors, condensation of metallic vapors; (5) chemical reaction: production of chemical smokes in industrial plants; and (6) various natural origins. The method of collecting and separating dust particles and the influence of air-borne matter on the health of the worker are discussed. H.E.S.

Basic principles of industrial sanitation. J. M. DALLA VALLE AND R. R. JONES. *Amer. Jour. Pub. Health*, **30** [4] 369–84 (1940).—To provide adequate industrial sanitation, attention should be paid to water supply and drinking facilities, toilets and washrooms, personal services (lockers, drying of work clothes if necessary, women's rest rooms, etc.), and disposal of air-borne contaminants, both dusts and fumes. Tables show the requirements of each of these items, based on the number of employees. B.C.R.

Cement does not cause silicosis. ANON. *Eng. News-Record*, **125** [5] 44 (1940).—In a recent study of 2278 employees in the cement industry, only 8 showed any evidence of nodular fibrosis attributable to dust. In 11 cement plants the rate of chronic infection of the lungs averaged less than that for the general public. B.C.R.

Ceramic art work at the Department of Fine Arts, Ohio State University. ANON. *Ceram. Age*, **36** [3] 75 (1940).—A page of illustrations of salt-glazed stoneware and earthenware tile is presented. F.G.H.

Ceramic laboratories at Missouri School of Mines and Metallurgy. ANON. *Ceram. Age*, **34** [5] 142 (1939).—A page of illustrations is presented. F.G.H.

Ceramic schools in 1940. ANON. *Ceram. Age*, **35** [6] 171–95 (1940).—A survey of the following ceramic institutions is given, including detailed information on their establishment, courses of instruction, laboratories and facilities, faculty, and graduates: (1) Univ. of Alabama, (2) Georgia School of Technology, (3) Univ. of Illinois, (4) Iowa State College, (5) Massachusetts Inst. of Technology, (6) Missouri School of Mines, (7) New York State College of Ceramics at Alfred Univ., (8) Univ. of North Carolina, State College Unit, (9) Univ. of North Dakota, (10) Ohio State Univ., (11) Pennsylvania State College, (12) Rutgers Univ., (13) Virginia Polytechnic Inst., (14) Univ. of Washington, (15) West Virginia Univ., (16) Univ. of Oklahoma, and (17) Carnegie Inst. of Technology. Illustrated. F.G.H.

Clinical studies and animal experimentation on pneumoconiosis caused by aluminum. G. GORALEWSKI. *Arch. Gewerbepath. & Gewerbehyg.*, **9**, 676–78 (1939).—G. wondered if aluminum dust would produce harmful changes in the lungs as do the better-known industrial dusts. His

review of recent literature showed that some authors declared aluminum and bronze-coloring plants to be among the dustiest. In 1938, two workers from the aluminum and bronze-coloring plant in Frankfort were placed under his professional care for several months. Both men had worked in quarters filled with fine aluminum dust; one of them had also been in the copper-stamping division. Both had broken down suddenly with an attack of short breathing; spontaneous pneumothorax had occurred in both cases, but not in the same corresponding lung. These indications, together with not very pronounced Roentgen shadows, had resulted in a preliminary diagnosis of "near tuberculosis" before the men came to G. The plant work spaces and machinery, when examined, were loaded with dust, and the clothing of the workers was permeated with it; for hours after work their nasal secretions were filled with aluminum dust. During the intensive and detailed clinical and laboratory study given these cases, G. found the disease picture baffling for months. The X rays continued unchanged; lack of tubercular clues in their families and histories and the absence of indispensable tubercular signs and developments left the tubercular etiology unconvincing. This was also the case with pneumoconiosis, since spontaneous pneumothorax has been observed in silicosis animal experimentation resorted to, with both aluminum and copper dusts profusely inhaled by rabbit series resulting in histological evidence similar to that already described by experts in dusts from porcelain and steel abrasives. The most pronounced indications were the growth of connective tissue in the alveolar septae and its absence after further encroachments in the cells. Interstitial pneumonia foci existed at beginnings of the alveolar changes. In spite of these minimal findings, G. is convinced that they are fundamental in ranging aluminum and copper dusts with the dangerous lung invasions and that further and extensive research will have justifiable results. K.R.

Compulsory licensing of patents. E. H. Waters. *Glass Ind.*, **20** [6] 221–22, 230 (1939).—Important features of compulsory licensing are presented as arguments against amendments to the present patent law. A.P.

Danger of silicosis and poisoning in the mixing rooms. Zschacke. *Glashütte*, **70** [29] 361–62 (1940).—The dangers of poisoning from many of the raw materials of glass, especially arsenic, fluorine compounds, and lead compounds, are explained. Finely powdered substances also have a harmful effect; soda dust has an irritating action on the mucous membrane of the nose, and silica dust causes silicosis. Replacement of hand mixing by machine mixing is of value only if the machines are dust-tight. Pot workers are especially subject to silicosis because of the silica dust produced. M.V.C.

Defense program and the ceramic industry. Rexford Newcomb, Jr. *Ind. Marketing*, **25** [9] 56 (1940).—Industrial and housing expansion will call for great quantities of window and plate glass, floor and wall tile, and sanitary ware. The construction program of the Navy will consume tremendous amounts of glass wool, ceramic tile, sanitary ware, refrigerators, ranges, pottery, and glassware. The Quartermaster's Corps of the Army will have to buy glass and dinnerware. Housing facilities to be built for the Army will require sanitary ware, tile, and glass. Optical-glass manufacturers will be busy for many months to come; because of a shortage in this line the Army is proposing the construction of a government operated optical glass plant in Chicago. Airplane production will greatly increase the consumption of safety glass. F.E.S.

Detection of silica-containing dust in lung tissue by means of fluorescent microscopy. Margarete Oberdalhoff. *Arch. Gewerbepath. & Gewerbehyg.*, **9**, 435–42 (1939).—O. summarizes briefly the methods in present use for determining the silica content of occupational dust: (1) chemical analysis; (2) use of the polarizing microscope, (3) Roentgen fine structure films, (4) dark-field illumination, and (5) the Giese microscopical method. Recently a 6th method, fluorescent microscopy, has been applied. Previous use of fluorescence in mineralogy is mentioned, and certain preliminary processes needed before its application as a test for quartz dust in the lung are sketched. O.'s procedure, given in full, involved the use of human and of animal lung tissue, notably specimens from wild rabbits and their young whose lungs were, of course, free from industrial dusts; a research series of tame rabbits long subjected to quartz-dust inhalations was also studied. In all of these silicotic lung specimens, only fluorescent crystals were identified. Necessarily, only the quartz crystals (having double refraction) could act in this way, a fact confirmed by research with the polarization microscope. O. reviews the preliminary studies by which she devised her procedure with the fluorescent microscope, so that quartz dust in lung tissue would become visible through coloring with fluorescent solutions (the so-called fluorchromes). Her technique is simple and requires little time and effort. After a short treatment (5 to 10 min.) with ether alcohol, the prepared material is colored with auramin and rinsed with distilled water. The quartz-dust particles stand out clearly from the more weakly colored fluorescent tissue as yellow-gold fluorescent crystals and are quickly and easily identified. The self-luminous character of the quartz particles makes possible the visibility of smaller forms than were ever before distinguished. This demonstration is believed to qualify the method as competent in dust research. K.R.

Explosibility of aluminum powder-silica dust clouds. Ralph B. Mason and Cyril S. Taylor. *Ind. Eng. Chem.*, **32** [1] 67–68 (1940).—The effect of silica dust on the explosibility of aluminum powder-silica dust clouds in air was studied in connection with the use of aluminum powder as an agent for the prevention of silicosis. When the silica content was twice the concentration of the aluminum powder, no explosion resulted. The effect is similar to that of rock dust in preventing coal-dust explosions. F.G.H.

Fight against silicosis among sandblasters. Anon. *Glashütte*, **70** [25] 316 (1940).—Sandblasters are particularly exposed to the danger of contracting silicosis. Sandblasting apparatus cannot be made wholly dust-tight because the finest invisible particles of sand dust sift through joints in the casing. Protective helmets are of some benefit. Strict medical supervision of the workers is indispensable in detecting first symptoms. Changing the occupation of blasters and shifting the workers regularly are advisable, but the best protection is the substitution of steel sand for quartz sand in blasting. M.V.C.

Formation of aggregates and structures in dilute solutions of hydrogen bentonites. J. N. Mukherjee and N. C. Sen Gupta. *Nature*, **145** [3686] 71–72 (1940).—Air-dried hydrogen bentonite has the same specific gravity in both water (2.248) and toluene (2.249). The fact that there is a slight diminution of density and not an increase is explained by the authors on the basis that clay minerals of the montmorillonite group show a strong swelling in water as a result of the penetration of water molecules into the lattice. If the resulting free space in the lattice is not completely filled by water molecules, the apparent specific gravity will decrease. With an increase of concentration, aggregates form; then a structure develops, and a yield value results. Thixotropy comes next. Coacervation appears generally after the development of the yield value but may appear before or after thixotropy develops. Six curves show the results of measurements obtained on a fraction of hydrogen bentonite (radius 12.5 to 25 mμ). J.L.G.

German glassware trust is serious menace to future of American glassware industry. J. M. Hammer. *Amer. Glass Rev.*, **59** [45] 11–12 (1940).—Ninety-six per cent of the hollow glass manufacturers have been organized into the Markt- und Leistungagemeinschaft der Hohlglasindustrie. Three cartels will be coordinated by a holding company (Glas Treuhand, G.m.b.H.). The cartel will use its influence toward rationalization of the industry in Germany, its provinces, and its protectorates. Defensive measures should be considered promptly. The American industry should be first in physical condition and must revitalize its selling. A.P.

Health problems. C. D. SELBY. *Amer. Jour. Pub. Health*, **30** [4] 336 (1940).—Owing to extensions in the scope of compensation, employers are occasionally responsible for certain ordinary diseases. Industrial doctors are broadening their occupational disease programs to include measures for the prevention of disabilities from ordinary sickness. B.C.R.

Laboratory activities at Iowa State College and the University of Washington. ANON. *Ceram. Age*, **36** [2] 45 (1940).—A page of illustrations is presented. F.G.H.

Lead poisoning from unusual causes. NELL CONWAY. *Ind. Med.*, **9** [9] 471–77 (1940).—C. reviews unrecognized lead hazards in unexpected places and unusual forms. Lead colics from beverages have occurred since early times, caused largely by the use of leaden vessels in cooking and wine making. In the 18th century, white lead was used to sweeten sharp and harsh wines until it was forbidden by drastic laws in Germany, Italy, and France. Modern cases still appear in Austria, England, and the U. S. from the careless use of leaden vessels. Lead poisoning from food has been more rare, although in Germany during the World War plum jam cooked in earthenware kettles enameled with a lead-containing glaze caused widespread poisoning. A century and a half ago snuff gave rise to poisoning, from the use of lead chromate to improve the color and the lead in the foil wrappings. Numerous studies of lead in connection with the use of smoking tobacco revealed only one case of poisoning. Lead arsenate sprayed upon tobacco plants has been suspected as poisonous but has not yet been proved so. Two cases of poisoning have occurred in golf professionals who worked-in a handful of white lead paint to make used balls resalable, rotating the balls between their palms. White lead dust used by an employee in the Criminal Identification Bureau of the Copenhagen police department to identify fingerprints on articles caused poisoning; he first dusted the articles with finely pulverized lead and, after brushing off the lead, bent over them to detect possible prints. Lead in cosmetics, in drugs, and in connection with bullets is also discussed, with examples. 152 references. K.R.

Lead poisoning in vascular disease. IRVING S. WRIGHT. *Ind. Med.*, **9** [9] 467 (1940).—Lead, manganese, and other metals are capable of producing vascular changes, lead being considered the major industrial hazard. At present, however, this is open to question. Vascular changes appear to depend on long-continued exposure and to be in the form of an early development of sclerosis-like changes in the arteries and veins. In patients 30 to 40 years old, the entire major vessel trees of both legs, arterial and venous, could be clearly made out on ordinary flat X-ray plates. Customary occupations producing such conditions are painting, plumbing, and printing. Lead-poisoning symptoms commonly resemble those of polyneuritis, but, when advanced enough, the vascular changes produce atrophy of the tissues, intermittent claudication, and trophic changes. Gangrene rarely, if ever, develops from lead poisoning alone. K.R.

Massachusetts Institute of Technology builds expert models. ANON. *Ceram. Age*, **36** [4] 101 (1940).—Models depicting pottery and glass plants of the 19th century are described and illustrated. F.G.H.

Metal-cleaning hygiene. INDUSTRIAL HYGIENE CODES COMMITTEE OF THE AMERICAN FOUNDRYMEN'S ASSN. *Foundry Trade Jour.*, **61** [1218] 429–30; [1219] 442 (1939).—The necessary engineering data for the design and operation of metal-cleaning units and processes as well as specifications for the personal protection of workers engaged in metal cleaning are submitted with the purpose of supplying industry with sufficient data and recommendations to provide adequate protection for workers. H.E.S.

New products needed in ceramics. ANON. *Ceram. Age*, **36** [4] 102 (1940).—Developments that would be valuable to the ceramic industry are reviewed. F.G.H.

Northern California Section interplant safety contest. C. L. BARR. *Bull. Amer. Ceram. Soc.*, **19** [10] 412 (1940).

Pacific Coast Borax Company celebrates fiftieth anniversary. ANON. *Bull. Amer. Ceram. Soc.*, **19** [10] 417 (1940).

Pathological changes induced by lead and some of its compounds. J. W. MILLER. *U. S. Pub. Health Bull.*, No. 253, pp. 33–40 (1940).—The pathological material of this research was obtained from guinea pigs used in determining the toxicity of lead and its compounds (see "Relative. . . , this issue). A total of 2800 histological sections from 230 guinea pigs was studied. The preparation of the specimens and the methods of studying them are described; results incident to lead exposures and the fatality of the animals are compactly tabulated. Exposure intervals varied from 1 to 407 days. The principal pathological findings were (1) fatty metamorphosis of the liver, due to toxic action of the lead compounds on the cells; (2) coagulation neurosis and capillary congestion, occurring in the liver to a much less degree; (3) hemosiderosis and interstitial hemorrhages in the pulp of the spleen and congestion of cavernous veins; (4) subacute bronchopneumonia in the lungs, with acute diffuse pneumonitis; (5) an excessive amount of dust in the lungs of animals exposed to the lead material by inhalation; and (6) subacute interstitial nephritis in about 20% of the animals. Lead compounds injected into the peritoneum resulted in slow absorption of the material and the formation of nodules. 4 references. K.R.

Physical chemistry of flotation: IX, Adsorption of xanthates by activated carbon and graphite and its relation to the theory of flotation. IAN WILLIAM WARK AND ALWYN BIRCHMORE COX. *Jour. Phys. Chem.*, **41**, 673–77 (May, 1937); *Metals & Alloys*, **8** [11] MA658 (1937).—The adsorption of the xanthates by sugar charcoal was studied, and an attempt was made to interpret it in terms of exchange adsorption reactions. Some K ion is adsorbed simultaneously with the xanthate ion. Alkali is liberated corresponding to the difference between the xanthate and potassium ions adsorbed. Addition of alkali decreases the amount of xanthate adsorbed in a given time. Cyanide is without marked effect. With graphite, the xanthate ions abstracted and the alkali liberated are approximately equivalent, little or no K being abstracted. A sample of sugar charcoal prepared by carburizing sugar with sulfuric acid was more active than a sample prepared by thermal carburization. The xanthates are flotation collectors for sugar charcoal. It is concluded that the flotation of graphite by xanthates is not due to any metallic impurities contained therein.

Protecting the employees' health. R. C. HEARD. *Gas Age*, **86** [7] 27 (1940).—To prevent loss of time due to the common cold, two capsules of cod-liver oil per day were supplied to the employees. The beneficial results more than justified the small expense of the oil. There is some doubt, however, whether additional vitamin A in diets not deficient in it is of any value. B.C.R.

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